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THE FINANCIAL STATUS OF WATER WORKS IN THE UNITED STATES AS OF JANUARY 1, 1924

BY LEONARD METCALF[1]

Barring the railroads the water works of this country were the first of the great public utilities. They were the first of the non-competitive utilities, antedating the other important ones of this group—the telephone, gas, electric light, traction and power companies.

It is a singular fact, however, that the water works of the country, the purveyors of one of the necessities, not only of industry, but of life itself, should have had a chequered financial career.

The majority of the water works in the United States were built in the last quarter of the last century, a few of the plants serving the older and larger cities having been established prior thereto. The exploitation of water works building and operation, as a source of profit, occurred in the late eighties and early nineties, and at the latter time several important failures, due to lack of financial sagacity, had a serious retarding influence upon development.

The state of the art advanced rapidly.

The serious menace of water-borne typhoid was effectively checked by the introduction and development first of long sedimentation, then slow sand, and finally rapid mechanical filtration, with the use of chemicals for coagulation. Then followed the development of chlorination and a general advance in standards of purity and

[1] Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

attractiveness, consideration being given not only to the safety of the water and low bacterial content, but to its freedom from turbidity, odor and color, and to its softness.

In 1905, or thereabouts, following the period of rapid development of the general public utility field, the making of large loans for betterments in anticipation of the future, with some abuse—though less than generally thought—there resulted the appointment in many states of the public utility commissions created to regulate the financial operations of public utilities and to reduce the rapidly multiplying litigation in this field facing the State and Federal courts.

Here again the problem was new and without precedent. It is not strange, therefore, that in the inflamed condition of the public mind the work of the commissions should have been seriously hampered and that property valuations fixed by them, and rates allowed, should have been lower than their own later experience has justified; but on the whole the work done by the commissions has been much to their credit and has served to stabilize values. It has suffered most from the short period of service of men appointed to these commissions. The appointment of new men has involved each time education in a highly specialized field. But with the development of experience, growth in precedent, and better methods of keeping records, and with the constant increase in decisions of the higher courts, this difficulty is being reduced and the attractiveness of the water works field for investment is being greatly improved.

There can be no doubt that without the commissions it would not have been possible to bridge the gap between prewar and postwar conditions, without the failure of many water works properties, the impairment of the borrowing capacity of others, and a very general lowering of the standard of service rendered to the public by them. Records seem to show that there was a delay of from eighteen months to two years on the part of the commissions, in giving relief to the water works through the agency of increased rates, and that the total cost to the water works of this country was probably well in excess of the sum of $250,000,000. This was in effect the contribution of this industry to the fighting of the Great War. This delay, or lag, is not to be wondered at, but it is the more surprising that in the face of it the commissions showed the courage to make the necessary increases at a later day notwithstanding falling prices—even though failure to do so would have brought serious injury, alike to the works and to the public, through impair-

ment of borrowing capacity and resulting increase in rate of interest to be paid.

Since the war the emergency relief granted by the commissions has been reviewed and there has been a very general revaluation of the properties. The effect of the reduced purchasing power of money created by the war, is being met step by step by the general, though in some cases enforced, recognition by the public utility commissions, of the mandate of the higher courts that economic considerations rather than arbitrary fiat must be given fair weight, and that present value rather than past cost should control in valuation and rate determinations. These advances in value of existing properties, as measured by the reduced purchasing power of the dollar, together with allowances for the higher operating costs, taxes and depreciation corresponding to the higher postwar level, promise to bridge successfully a very difficult period in the life history of these works.

Up to recent times water works securities have not had the same marketability as the securities in other public utility fields. They have not been generally quoted upon the large exchanges or been dealt in except by certain brokerage houses making a specialty of them.

These conditions have been due probably to the following causes:

1. Lack of information and precedent in the public utility field and of appreciation of the essential factors of the problem, growing out of the fact that the water works were the first of the noncompetetive utilities. For example, there was little appreciation of the extent of the overhead costs; the brokerage, interest-during-construction, and other costs incident to the attracting of money; and no conception of the cost and time involved in developing the business, which in the early days involved a period generally in excess of nine to twelve years and costs more substantial even than those of today.

2. Long-time contracts, fixing the rates for periods of twenty years, more or less, without means for readjustment to meet changing conditions.

3. Substantial advance over several decades, in cost of labor and in some cases in cost of materials.

4. The marked advance in quality standards such as the requirement of sedimentation, filtration and other treatment of the water at great cost to the water works, without increase in compensation.

TABLE 1

Index numbers of commodity prices

	DUN'S INDEX NUMBER		UNITED STATES DEPARTMENT OF LABOR†			DUN'S INDEX NUMBER		BRADSTREET'S INDEX NUMBER*		UNITED STATES DEPARTMENT OF LABOR INDEX NUMBER*†		ENGINEERING NEWS-RECORD INDEX NUMBER*	
		Percentage more or less than pre-war base		Percentage more or less than pre-war base			Percentage more or less than pre-war base		Percentage more or less than pre-war base		Percentage more or less than prewar base		Percentage more or less than pre-war base
1860	115.191°	−5			1892	90.105°	−26	7.7769	−15	75	−25		
1861	101.920°	−17			1893	90.613°	−26	7.5325	−17	77	−23		
1862	118.510°	−3			1894	83.292°	−32	6.6847	−27	69	−31		
1863	173.180°	+41			1895	81.519°	−33	6.4347	−29	70	−30		
1864	278.987°	+128			1896	74.317°	−39	5.9125	−35	67	−33		
1865	194.436°	+59			1897	72.455°	−41	6.1660	−32	67	−33		
1866	207.978°	+70			1898	79.393*	−35	6.5713	−28	70	−30		
1867	188.524°	+54			1899	86.509*	−29	7.2101	−21	75	−25		
1868	182.825°	+49			1900	93.526*	−24	7.8840	−13	81	−19		
1869	164.630°	+34			1901	95.853*	−22	7.5746	−17	79	−21		
1870	148.781°	+21			1902	100.407*	−18	7.8760	−13	84	−16		
1871	151.510°	+24			1903	99.035*	−19	7.9365	−13	86	−14		
1872	150.479°	+23			1904	100.172*	−18	7.9188	−13	86	−14		
1873	143.089°	+17			1905	100.574*	−18	8.0990	−11	86	−14		
1874	143.133°	+17			1906	105.348*	−14	8.4177	−8	89	−11		
1875	134.702°	+10			1907	111.796*	−9	8.9045	−2	94	−6		
1876	116.479°	−5			1908	109.866*	−10	8.0096	−12	90	−10		
1877	109.547°	−11			1909	117.780*	−4	8.5154	−6	97	−3		
1878	96.268°	−21			1910	118.802*	−3	8.9882	−1	101	+1		

1879	97.285°	−21			1911	116.802*	−5	8.7129	−4	93	−7		
1880	108.655°	−11			1912	124.401*	+2	9.1867	+1	99	−1		
1881	111.901°	−9			1913	120.887*	−1.4	9.2115	+1	100	0	100.00	0
1882	123.230°	+1			1914	122.211*	−0.2	8.9035	−2	98	−2	88.56	−11
1883	107.248°	−12			1915	126.393*	+3	9.8530	+8	101	+1	92.58	−7
1884	99.706°	−19			1916	148.808*	+21	11.8237	+30	127	+27	147.35	+47
1885	90.697°	−26			1917	204.121*	+67	15.6385	+72	177	+77	181.24	+81
1886	89.226°	−27			1918	229.220*	+87	18.7117	+106	194	+94	189.20	+89
1887	93.624°	−23			1919	230.846*	+88	18.6642	+105	206	+106	198.42	+98
1888	95.134°	−22			1920	247.888*	+102	18.8095	+107	226	+126	251.28	+151
1889	89.691°	−27			1921	170.797*	+39	11.3695	+25	147	+47	201.78	+102
1890	91.549°	−25	81	−19	1922	172.223*	+41	12.1185	+33	149	+49	174.45	+74
1891	96.092°	−22	80	−20	1923	189.788*	+55	13.4028	+47	154	+54	214.07	+114
					1924	189.323	+55	12.8672	+41	150	+50	215.36	+115

Note: For Dun's and Bradstreet's index numbers, the prewar base to which the "Percentage more or less than average" refers, is the average of the index numbers for the years 1912–1913 and 14. (Dun's = 122.500; Bradstreet's = 9.1006.) For the United States Department of Labor and Engineering News-Record Indexes the percentages refer to the index number for the year 1913. Dun's index numbers for years 1860 to 1897 inclusive, marked (°) are the numbers for July 1 of each year. For the years 1898 to 1923, they are the averages of the 12 monthly index numbers of the calendar year.

* Determined by averaging the 12 monthly index numbers of the calendar year.

† Based on 1919 census figures.

5. Burdensome litigation in connection with value and rating problems.

6. Increase in costs and decrease in purchasing power of money incident to and following the Great War.

The extent of some of the influences referred to are indicated by the statistics developed from the records of about 45 water works, both publicly and privately owned, serving a gross population of 9,800,000 (in 1923) during the eight-year period 1915 to 1923 inclusive. These statistics for the period 1915 to 1918 were developed by a committee of the American Water Works Association (Leonard

TABLE 2

Increases in Commodity prices over prewar basis, in per cent

YEAR	UNITED STATES DEPARTMENT OF LABOR (1919 REVISION)	DUN'S	BRADSTREET'S	ENGINEERING NEWS-RECORD
1916	27	21	30	47
1917	77	67	72	81
1918	94	87	106	89
1919	106	88	105	99
1920	126	102	107	151
1921	47	39	25	102
1922	49	41	33	74
1923	54	55	47	114
Average for 8 years........	73	63	66	95

Prewar basis, here used for:
United States Department of Labor: Year 1913.
Dun: Average of years 1912–1913–1914.
Bradstreet: Average of years 1912–1913–1914.
Engineering News-Record: Year 1913.

Metcalf, Chairman, George A. Johnson, George W. Fuller) appointed to report on "War Burdens of Water Works in the United States."[2] They were subsequently brought forward by Metcalf in two papers.[3] presented to the Association, and have been recently brought down by him to the end of the year 1923. The records were made possible through the courtesy and public spirit of the operators of these works.

[2] Jour. Am. W. W. Assoc., Vol. V, 1918, p. 304.

[3] "The War Burdens of Water Works in the United States Continue," Jour. Am. W. W. Assoc., Vol. VII, 1920, p. 471.

"The Improved Financial Condition of Water Works in the United States," Jour. Am. W. W. Assoc., Vol. IX, 1922, p. 685.

ADVANCE IN COMMODITY PRICES—INDEX NUMBERS

By way of comparison it may be helpful to the reader to present first the index numbers of various agencies as evidence of the advance in commodity prices during the period of years from 1860 to date.

Dun's index numbers are based on the weighted average wholesale quotation per pound (on first business day of each month) of about 300 commodities, obtained by weighting the actual cost of each commodity according to its annual per capita consumption in the United States. These commodities are grouped as follows:

Breadstuffs include wheat, corn, oats, rye and barley, beans and peas; meats include live hogs, beef, sheep and various provisions, lard, tallow, etc.; dairy and garden include butter, eggs, vegetables and fruits; other foods include fish, liquors, condiments, sugar, rice, tobacco, etc.; clothing includes the raw materials of each industry, and quotations of woolen, cotton and other textile goods, as well as hides and leather; metals include various quotations of pig iron, and partially manufactured and finished products, as well as minor metals, coal and petroleum. The miscellaneous class embraces many grades of hard and soft lumber, lath, brick, lime, glass, turpentine, hemp, linseed oil, paints, fertilizers and drugs.

Bradstreet's index numbers represent the summation of the wholesale prices per pound (on the first business day of each month) of about 96 common commodities, grouped as follows:

Breadstuffs, livestock, provisions, fruits, hides and leather, textiles, metals, coal and coke, oils, naval stores, building materials, chemicals and drugs, miscellaneous.

The United States Department of Labor, Bureau of Labor Statistics index number is computed from wholesale prices of commodities weighted according to the quantities of the various commodities marketed in the census years.

The 1910 index was based upon the 1909 census. Beginning with May, 1922, the computation was revised to include the prices of 404 commodities weighted according to quantities marketed in the census year, 1919.

Engineering News-Record, Construction Cost index numbers are based upon 1913 as 100. This index is computed from the prices of

Steel, cement, lumber and common labor, the great basic items entering into nation wide construction. They are weighted as follows: Steel 37.50 per cent, cement 7.14 per cent, lumber 17.10 per cent, labor 38 per cent, determined by studying the annual production of the three prime materials, and the number of common laborers in the United States (excluding farm laborers).

TABLE 3

Summary of data upon increase in cost of unskilled labor and materials to water works in the United States, from prewar basis (characterized by 1915 costs) up to 1923

ITEM	NUMBER OF RECORDS ON DIFFERENT YEARS	PRICES PER UNIT									PER CENT INCREASE OVER 1915 (PREWAR BASIS)							
		1915	1916	1917	1918	1919	1920	1921	1922	1923	1916	1917	1918	1919	1920	1921	1922	1923
1. Unskilled labor in cents per hour:																		
a. Eastern group	15–18	23.0	26.7	30.4	40.2	43.8	52.5	43.4	44.4	51.6	16	32	75	91	128	89	93	124
b. Central group	17–12	21.7	25.3	26.9	37.2	36.8	47.1	40.9	37.4	43.5	17	24	71	70	117	88	72	100
c. Southern group	6–12	17.9	20.6	24.5	34.3	34.4	42.1	35.7	38.2	36.2	15	37	92	92	135	99	113	102
d. Western group	7– 8	27.0	28.5	31.4	41.8	46.4	54.7	53.5	49.7	50.4	5	16	55	72	105	98	84	87
e. Average of groups		22.4	25.3	28.3	38.4	40.4	49.1	43.4	42.4	45.4	13	27	71	80	121	94	91	103
2. Cast iron pipe per 2000 pounds approximate, in dollars	17–44	24.23	30.70	51.60	67.74	69.20*	76.53	52.30	47.85	56.64	27	113	179	184	216	116	98	134
3. 6-inch valves, in dollars	11–40	11.18	12.64	19.13	19.13	20.73	24.72	21.93	21.54	23.64	13	71	71	85	121	96	93	111
4. 12-inch valves, in dollars	3–38	34.78	41.53	65.22	65.02	59.66	68.90	62.13	62.43	64.99	19	88	87	72	98	79	79	87
5. 2-way hydrants, in dollars	6–38	26.69	32.04	43.13	51.80	47.16	52.30	47.10	57.17	63.00	20	62	94	77	96	77	114	136

6. Coal, per 2000 pounds, in dollars:																		
a. Eastern group	13–16	2.98	3.80	5.96	6.00	5.41	7.34	5.81	6.89	6.01	27	100	101	82	146	95	131	102
b. Central group	8–12	2.41	2.77	3.75	4.53	4.55	5.84	5.69	5.46	4.64	15	56	88	89	142	136	127	93
c. Southern group	17–12	1.92	2.01	3.03	3.89	3.78	5.35	4.45	4.13	3.22	5	58	102	97	179	132	115	68
d. Western group†	5– 4	3.97	4.37	6.31	7.92	4.70	5.60	5.29	5.35	3.92	10	59	99	18†	41	33	35	−1
e. Average of groups in dollars		2.82	3.24	4.77	5.57	4.61	6.03	5.31	5.46	4.45	15	69	97	72	127	99	102	65
7. Fuel oil, in cents per gallon:																		
South	1–3	1.80	1.80	2.00	4.28	—	2.35	2.93	3.07	2.63	0	11	138	—	30	62	71	46
West	1–4	1.38	1.50	2.57	4.05	4.09	4.16	4.16	2.74	2.21	9	86	193	197	201	201	99	60
8. Alum, per pound, in cents:																		
a. Eastern group		1.12	1.72	1.48	1.45	1.66	1.90	1.75	1.63	1.55	54	33	29	48	69	57	46	38
b. Central group		0.91	0.91	1.25	1.50	1.40	2.66	1.86	1.80	1.62	0	37	65	54	192	104	98	78
c. Southern group		1.08	1.38	1.48	1.78	1.56	2.17	1.81	1.94	1.68	28	37	65	44	101	67	80	56
d. Western group		1.14	1.21	1.51	1.53	1.79	2.04	2.23	2.92	2.45	6	32	34	57	79	96	156	115
e. Average of groups, in cents		1.06	1.30	1.43	1.56	1.60	2.19	1.91	2.07	1.83	22	35	47	51	110	81	95	72

* Range $50.60 to $83.50 per ton.

† Small number makes record of doubtful value.

Of these indexes that of the Engineering News-Record has been the most significant as applied to water works practice, because of the fact that the units upon which the index number is based are much more nearly in accord with water works requirements than are those of the other agencies.

In table 2 are shown in concise form for the eight-year period (1916–1923) the increases in commodity prices over prewar basis, in per cent, for each of the years in question, and the average for the period as found by the several agencies. The average of Dun's, Bradstreet's and United States Department of Labor indexes is about 52 per cent for the year 1923, and 67 per cent for the period; and of the Engineering News-Record index numbers, most significant in water works practice, 114 per cent for the year 1923 and 95 per cent for the eight-year period.

Recent valuations of water works indicate that fair reproduction costs are somewhat over double prewar reproduction costs.

ADVANCE IN COST OF LABOR AND MATERIALS

In table 3 is shown a summary of data upon the increase in cost of unskilled labor and materials, from prewar basis to that of the year 1923.

Labor costs. The cost of contract labor such as ordinarily used in construction, was much higher during the war period and is still slightly higher than that of the permanently employed labor used in maintenance and operation of water works properties. It is to be borne in mind, too, that the figures reported make no allowance for the loss in efficiency of labor during the war period. This loss was substantially as great as the increase in cost itself, thus in effect doubling the cost increases of the war period. For instance, at the time of maximum prices in the year 1920, when the increase in cost of labor was about 120 per cent over prewar prices, it was the general opinion that the efficiency of labor was but one-half as great as under prewar conditions. Fortunately prewar efficiency was substantially regained in the year 1923.

The average cost of unskilled labor increased from 22.4 cents per hour to a maximum of 49.1 cents (121 per cent) in 1920, fell gradually to 42.4 cents per hour in 1922, then rose to 45.4 cents in 1923 and a somewhat higher point in the year 1924. The present cost of unskilled labor is somewhat more than double prewar basis.

The data both as to prices and percentage changes are shown in diagrammatic form in figure 1.

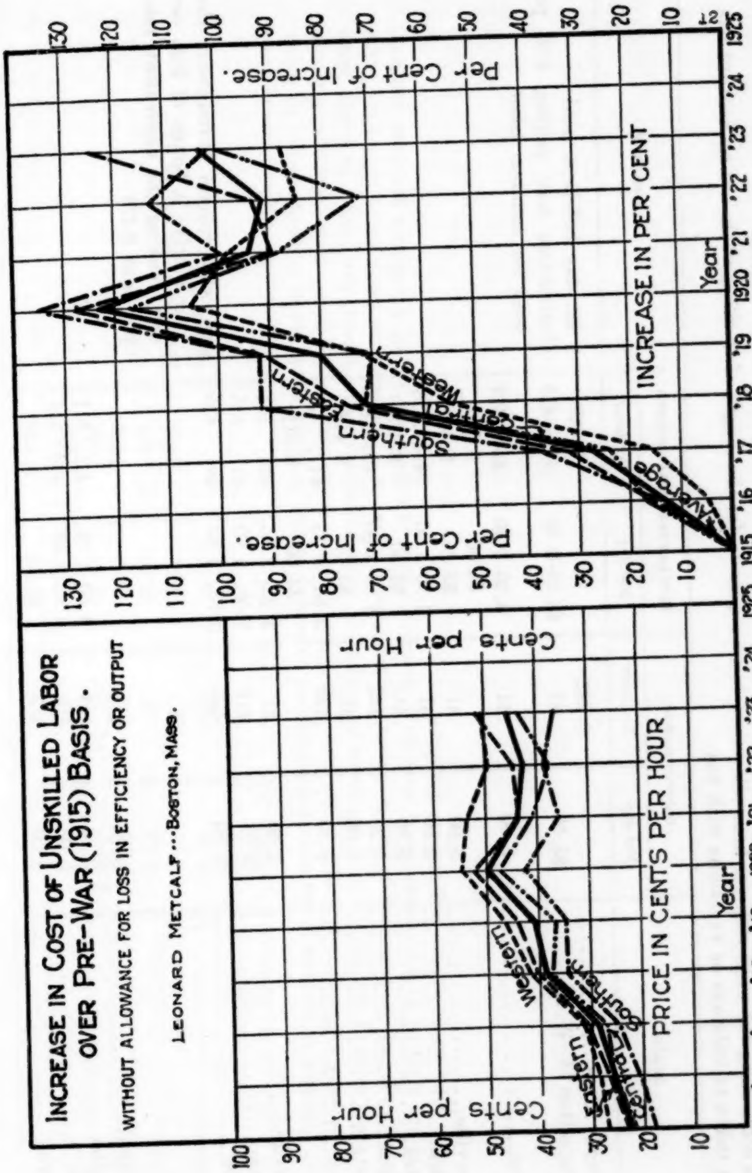
INCREASE IN COST OF UNSKILLED LABOR
OVER PRE-WAR (1915) BASIS.
WITHOUT ALLOWANCE FOR LOSS IN EFFICIENCY OR OUTPUT
LEONARD METCALF ... BOSTON, MASS.
PRICE IN CENTS PER HOUR
Cents per Hour
INCREASE IN PER CENT
Per Cent of Increase.
Year
Eastern
Central
Southern
Western
Average
1915
'16
'17
'18
'19
1920
'21
'22
'23
'24
1925

FIG. 1

TABLE 4

Wages paid in municipal water works near Boston, September 14, 1918

In computing the wage rate per hour allowance has been made for the length of working week, but no account has been taken of holidays or vacations with pay.

PLACE	COMMON LABOR		PIPE LAYERS AND CAULKERS		REMARKS
	Per day	Per hour	Per day	Per hour	
Concord, Mass.		0.382		0.418	9 hr. day holidays paid
Metropolitan W. W.	$3.00	.41	$3.25–3.50	.444–.478	Contractors now paying $.50 per hour for common labor
Boston	3.00	.41	3.25–3.50 $4.00	.444–.478 $.546	
Somerville	3.00	.41	$3.25	$.444	
Malden	3.00	.41	3.25–3.50	.444–.478	
Chelsea	3.00	.41	$3.50	$.478	
Newton	3.25	.444	3.25–3.50	.444–.478	
Everett	3.00	.41	$3.25	$.444	
Quincy	3.30	.421	3.50, 3.75 $4.00	.447, .479 $.511	
Medford	3.00	.41	3.25, 3.75	.444, .511	
Melrose	3.25	.417	3.50, 4.00	.45, .515	
Revere	3.50	.453	3.75, 3.83	.486, .495	Men who remain throughout the year receive a bonus of $.25 per day, making the equivalent rate per hour $.478
Watertown	3.25	.444			
Arlington	3.25	.444	3.50–3.75	.478–.511	
Milton	3.03	.413	3.63–3.93	.494–.535	
Winthrop	3.00	.375	$3.50	$.438	

Lexington	3.00	.375	3.25	.406	
Belmont	3.00–3.25	.41–.444	3.25	.444	
Cambridge	3.25	.444	3.50	.478	
Brookline	3.25	.418	3.50	.471	
Waltham	3.00	.39	3.50	.454	Men now on strike
	3.25	.418			Granted 9/16/18
Marlboro	3.50				
Hudson	3.50				

Note: Practice in various departments with regard to length of the working week varies considerably. In many the 44-hour week is observed throughout the year. In some, 44 hours is the time during 3, 4 or 5 months, and 48 hours for the remainder of the year. In a few cases 48 hours per week are worked throughout the year. In many cases two weeks vacation without loss of pay is allowed to permanent men; in a few cases no vacation is allowed. Legal holidays are allowed to permanent men, with pay, in many cases; in others, only 3 or 4 holidays per year are paid for, and in some cases no pay is given for holidays.

TABLE 5

Labor prices paid by water works in the vicinity of Boston (August 19, 1924)

"Actual rates" signifies corrected for hours worked, holidays, etc.

PLACE	UNSKILLED LABOR PER DAY—NOMINAL RATES	UNSKILLED LABOR PER HOUR—ACTUAL RATES	PIPE LAYERS AND CAULKERS PER DAY	PIPE LAYERS AND CAULKERS PER HOUR	HOURS PER WEEK	HOLIDAYS	VACATION, TWO WEEKS PAID	INCREASE IN WAGES ANTICIPATED
1. Boston	4.50	0.659	5.00–5.50	0.732–.804	44	Paid	Yes	No
2. Somerville	4.32	.631	4.48	.655	44	Paid	Yes	No
3. Newton	4.72	.660	4.96	.694	44	Paid	No	No
4. Lexington	4.00	.520	4.40–4.80	.572–.624	48	Not paid	Yes	No
5. Waltham	5.00	.732	5.50	.804	44	Some	Yes	No*
6. Everett	4.50	.659	4.50	.659	44	Paid	Yes	No
7. Chelsea	5.00	.732	6.58	.959	44	Paid	Yes	No
8. Quincy								
9. Medford	4.75	.690	5.00–5.50	.732–.804	44	Paid	Yes	No
10. Melrose								
11. Revere	5.00	.732	5.50	.804	44	Paid	Yes	No
12. Watertown	5.00	.732	5.75	.842	44	Paid	Yes	No
13. Arlington	3.75– 4.50	.550– .659	5.25	.767	44	Paid	Yes	No
14. Milton	4.50	.619	5.50– 6.00	.753– .882	44 48	Paid	Yes	No
15. Winthrop	4.50	.601	4.80	.642	48	Paid	Yes	No
16. Cambridge								
17. Brookline	4.50	.601	4.92	.653	48	Paid	Yes	No
18. Marlboro	5.00	.625	5.00	.625	48	No	No	No
19. Hudson	4.00	.535	5.00	.669	48	Paid	Yes	No

20. Fitchburg	4.00– 4.80	.550 .660	5.00	.737	45	Not paid	Yes	No
21. Beverly	4.50	.659	Salary per year		44	Paid	Yes	No
22. Malden	4.75	.695	5.00	.732	44	Paid	Yes	No
23. Concord, Mass.	4.40	.55	4.50	.563	48	No	No	No

* All common laborers were raised to $5.00 August 11, 1924. The men who were hired for summer work since May 1 had been getting $4.64 per day.

TABLE 6

Wage scales of building trades crafts in Indianapolis, Ind. in dollars per hour

	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
Cement finishers per hour	0.50	0.55	0.57½	0.57½	0.60	0.65	0.70	1.00	0.90	0.90	0.95	1.05
											1.25	1.25
Structural iron setters	.65	.70	.70	.70	.75	.75	.75	1.25	1.15	1.12½	1.35—3 men	1.35
											1.50—5 men	1.50
Ornamental iron workers	.65	.70	.70	.70	.75	.75	.75	1.25	1.15	1.12½	1.25-1.50	1.25
Carpenters	.50	.50	.55	.55	.57½	.60	.75	1.00	.92½	.92½	.975 and 1.075	1.10
Sheet metal workers	.45	.47½	.55	.55	.57½	.60	.75	1.00	.92½	.92½	.97½	1.10
Painters	.47½	.50	.50	.50	.55	.65	.70	1.00	.92½	.90	.97½	1.10
Plumbers	.62½	.62½	.65	.67½	.67½	.81¼	.87½	1.25	1.15	1.12½	1.22½	1.25
Steam fitters	.62½	.62½	.65	.67½	.67½	.81¼	.87½	1.25	1.15	1.12½	1.22½	1.25
Electricians	.45	.47½	.50	.53	.57	.67½	.75	1.00	1.00	1.00	1.12½	1.10
Brick layers	.75	.75	.75	.75	.75	.85	1.00	1.25	1.15	1.15	1.35 and 1.45	1.50
Asbestos workers	.45	.47½	.47½	.47½	.55	.60	.75	.90	.80	.80	.90	1.10
Hod-carriers	.40	.40	.40	.42½	.45	.50	.57½	.72½	.67½	.67½	.725 and .75	.85
								.75	.70	.70		
Plasterers	.62½	.62½	.67½	.67½	.75	.75	.87½	1.12½	1.12½	1.12½	1.37½	1.50
								1.00	.92½	.90	1.15	1.15
Hoisting engineer	.60	.65	.65	.65	.70	.72½	.72½	1.12½	1.02½	1.00	1.25	1.25
								1.25	1.15	1.12½	1.35	1.35

Three way scale—1920.

TABLE 7

Cost of labor and materials to Indianapolis Water Company

	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
Laborers	0.175	0.185	0.20	0.20	0.20	0.225	0.25	0.275	0.45	0.45	0.35	0.35	0.45	0.45
Calkers and yarners	.20	.225	.225	.225	.225	.25	.275	.30	.45	.50	.45	.45	.50	.50
Street foremen	.43	.43	.43	.43	.46	.47	125.00*	135.00*	150.00*	165.00*	200.00*	200.00†	200.00	200.00
													.55	.55
Meter men installers, per month							80.00	90.00	95.00	120.00	125.00	125.00	140.00	140.00
Repairmen per month							60.00	75.00	80.00	95.00	100.00	100.00	130.00	125.00
Team and driver	.43	.45	.45	.45	.45	.50	.60	.60	.70	1.00	.80	.80	.80	.80
2 x 4 inches Y. P.	23.00	23.00	21.00	26.00	28.00	28.00	37.00	40.00	65.00	55.00	42.00	40.00	45.00	43.00
1 x 6 inches No. 1 Com. Flg.	30.00	30.00	30.00	32.50	35.00	33.00	42.00	50.00	85.00	75.00	60.00	65.00	65.00	58.00
Cement net	1.00	1.00	1.20	1.18	1.23	1.68	2.03	2.18	2.13	2.58	2.23	2.11	2.51	2.80
Allowance for sacks each	.10	.10	.10	.10	.10	.10	.10	.10	.10	.25	.10	.10	.10	.10
Total price	1.40	1.40	1.60	1.58	1.63	2.08	2.43	2.58	2.53	3.58	2.63	2.51	2.91	3.20
Cost of cement in yards	1.13	1.13	1.33	1.32	1.38	1.84	2.20	2.37	2.34	2.90	2.48	2.34	—	—
Brick Comm. f.o.b. Ind.	8.00	8.00	8.00	8.00	8.50	9.00	10.00	14.00	14.00	16.50	17.50	14.50	15.75	14.00
Glazed brick										60.00	40.00	28.00	30.00	34.00
Face brick	12.00	12.00	12.00	12.00	12.75	13.50	15.00	21.00	21.00	25.00	28.00	19.00	23.75	23.75
Workmen's compensation and public utility insurance rate per $100 of payroll applicable to laying mains					$4.00	2.984	3.503	5.375	5.191	4.692	2.86	2.86	2.37	2.26
								(Average for ten years $3.61)						

* Per month.

† Asst.

TABLE 8

Prices paid for supplies used in operation and maintenance by Indianapolis Water Company f.o.b. Indianapolis

ITEM	UNIT	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
1. Coal	Ton	$1.45	$1.496	$2.439	$3.223	$3.123	$3.895	$4.10	$4.98	$3.70	$3.45
2. Screenings								3.90	3.98	3.45	2.95
3. Alum	100 pounds	.861	.936	1.479	1.881	1.747	1.764	1.65	1.43	1.285	1.28
4. Gasoline	Gallon	.125	.175	.215	.247	.258	.315	.25	.265	.21	.21
5. Coal oil	Gallon	.07	.08	.10	.119	.157	.23	.125	.122	.12	.12
6. Boiler tubes	4 foot	.1675	.2285	.55	.61	—	.625	.48	.37	.35	.35
7. Oil, Engine	Gallon	.179	.195	.25	.308	.37	.50	.50	.50	.50	.41
8. Oil, high power cylinder	Gallon	.349	.35	.44	.498	.60	.70	.63	.60	.58	.68
9. Oil, low power cylinder	Gallon	.234	.25	.34	.437	.60	.70	.63	.60	.53	.48
10. Rags (instead of waste)	Pound	.05	.06	.07	.08	.095	.105	.11	.10	.125	.185
11. Cast iron castings	Pound	.0292	.0325	.0411	.055	.065	.08	.075	.07	(.05¼–.06) .055	.055
12. Cast iron pipe	Ton	21.38	25.58	45.88	58.99	56.08	58.90	46.00	40.14	49.50	51.86
13. Lead	Pound								.0576	(.064–.083) 0.072	.0916

In tables 4 and 5 are shown the labor costs paid by a number of water works in the vicinity of Boston in the years 1918 and 1924; in table 6 are shown the wage scales of building trade crafts in Indianapolis for the years 1913 to 1924 inclusive; in table 7 are shown the costs of labor and materials, to the Indianapolis Water Company for the years 1911 to 1924; and in table 8 the prices paid for supplies used in operation and maintenance by the Indianapolis Water Company. The data of the latter company were assembled for submission to the Federal Court in the rating suit of the Company in 1924.

Cast iron pipe prices rose from a recorded prewar base of $24.23 per ton to a maximum (average) of $76.53 in 1920, though individual prices were nearly $100; fell to $52.30 in the year 1921; $47.85 in 1922; then rose to $56.64 in 1923; the average price for the year 1924 probably being slightly in excess of the latter figure. Cast iron pipe prices are therefore still more than double prewar costs.

The prices of valves and hydrants, which never reached so high a plane during the war as those of other material—continued to rise to the year 1920, about double prewar prices, and have remained even to the present time, at about this figure.

Coal prices rose rapidly to a maximum in the year 1920 of over double prewar prices, then fell gradually to a point about 60 per cent in excess of prewar basis in the year 1923, at or about which point they still remain.

ADVANCE IN GROSS AND NET ANNUAL REVENUES AND OPERATING EXPENSES OF WATER WORKS

The fluctuations in gross annual revenue, operating and maintenance expenses and taxes, and in net annual operating revenues (applicable to depreciation and return) expressed in percentage over prewar conditions, as exemplified by the year 1915, are shown in table 9 and in figure 2. These percentages have been determined by averaging the percentages found for each of the individual works reporting. They indicate the change in actual conditions but give no measure of the effect, upon these changes, of the growth in population during the eight-year period under review.

Similar records of gross and net annual revenues and operating expenses are given in table 10, showing the effect both upon privately and publicly owned works, and upon all of the works combined, of the growth in the eight-year period, expressed in per capita terms.

This form then does give weight to the increase in population. It is to be remembered, however, that in so long a period as eight years

TABLE 9

Increase in revenues and expenses of water works in the United States over those of 1915, in percentage

	1916	1917	1918	1919	1920	1921	1922	1923
Gross annual revenue:								
a. Eastern group	10.1	12.8	20.6	23.9	38.7	46.2	50.0	63.4
b. Central group	9.1	11.4	26.4	23.3	53.1	68.9	74.2	89.6
c. Southern group	7.5	20.3	26.3	26.3	45.9	57.5	66.8	86.3
d. Western group	7.3	9.5	17.5	25.0	35.6	51.9	61.9	84.8
Average	8.5	13.5	22.7	24.6	43.3	56.1	63.2	81.0
Operating expenses and taxes:								
a. Eastern group	21.9	41.1	49.7	50.4	97.5	101.6	91.1	99.8
b. Central group	9.3	37.3	62.3	63.1	129.0	143.9	133.7	153.4
c. Southern group	9.7	34.6	65.9	71.5	112.6	104.3	110.8	124.1
d. Western group	9.9	17.4	28.0	36.1	57.7	70.8	98.8	129.9
Average	12.7	32.6	51.5	55.3	99.2	105.2	108.6	126.8
Net operating revenues applicable to depreciation, interest, dividends and surplus:								
a. Eastern group	3.0	−9.6	5.8	14.0	5.1	15.7	36.5	52.1
b. Central group	10.0	−1.5	6.5	9.3	16.0	49.3	49.2	58.4
c. Southern group	−3.7	4.0	−10.9	−12.0	−8.5	9.3	21.8	54.2
d. Western group	4.3	5.3	14.4	22.1	29.6	42.3	42.8	64.0
Actual average annual increase over prewar 1915 basis	3.4	−0.4	4.0	8.4	10.6	29.2	37.6	57.2
Normal if compounded annually:								
At 2 per cent	2.0	4.0	6.1	8.2	10.4	12.6	14.9	17.2
At 3 per cent	3.0	6.1	9.3	12.6	15.9	20.4	24.0	28.8
At 4 per cent	4.0	8.2	12.5	16.9	21.7	26.5	31.6	36.9
At 5 per cent	5.0	10.3	15.8	21.6	27.6	34.0	40.7	47.7
At 5.84 per cent	5.84	11.2	17.8	24.8	32.2	39.7	48.0	57.2
At 6 per cent	6.0	12.4	19.1	26.2	33.8	41.8	50.3	59.4

a substantial increase in per capita return would be found for a fixed population, growing out of the general experience that consumers do

gradually extend their use of water by the adding of additional fixtures and facilities, which increases slightly the revenue derived by the works, from these services. The depreciation record for the year 1915 is not complete enough to be of significance. It is probable, however, that the per capita allowance at that time was not in excess of 25 cents per year—probably slightly less.

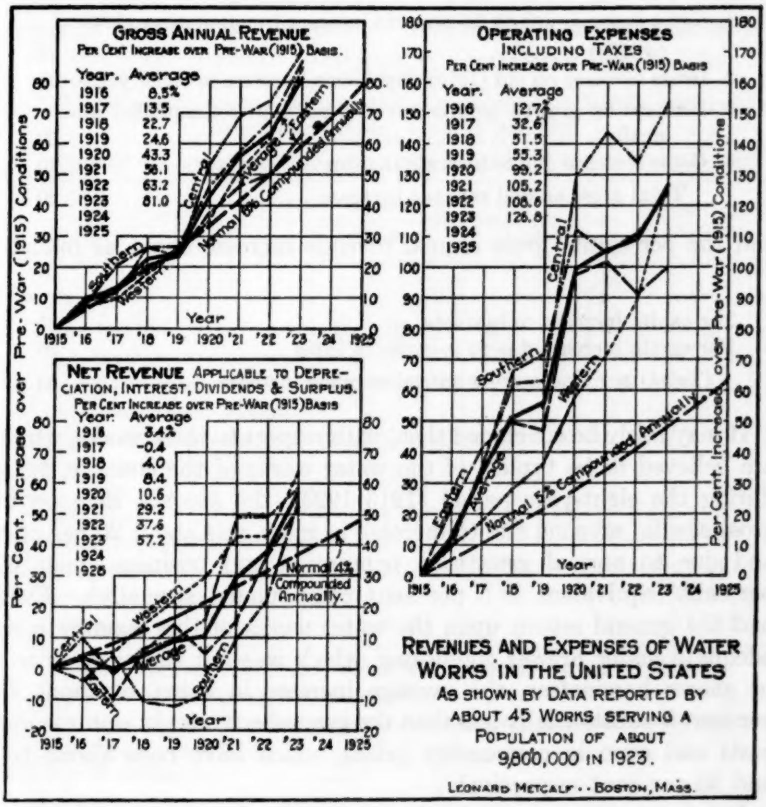

FIG. 2

The gross annual revenue rose fairly constantly from 1915 to 1919, then increased at a more rapid rate to the end of the year 1923 when the average over prewar basis was about 81 per cent, as shown in table 9 and figure 2.

The normal rate of growth for the plants under question, during this eight-year period, cannot be precisely determined, but may be

fairly approximated through a consideration of table 10, interpreted in the light of the past experience of water works. The latter indicates that on a per capita basis the increase has been about 50 per cent, on 1923 population, and 60 per cent on 1915 population.

The gross annual revenue increase, 81 per cent, may be divided about as follows:

	per cent
1. Gross increase due to 28 per cent increase in population (1915 to 1923)	25
2. Gross increase on old (1915) population business in eight years	35
3. Increase by growth (equivalent to 6 per cent compounded annually)	60
4. Gross increase due to increase in rates	20
Total gross annual revenue increase	80

and the per capita gross annual revenue increase about as follows:

	per cent
Per capita increase in business	35
Per capita increase due to increase in rates	20
(Total) per capita gross annual revenue increase	55

It may fairly be concluded then, with respect to these works, which are believed to be typical of the water works of the country, that, during the eight-year period (1915–1923), the average increase in gross annual revenue due to increase in rates, was about 20 per cent and due to normal growth in population and business about 60 per cent (equivalent to 6 per cent compounded annually). Even had the general return upon the water works of this country been adequate under prewar conditions, which was not the case, as will be shown hereinafter, the average increase in rates, of about 20 per cent is substantially less than the general advance in water works costs and even in commodity prices, which have been about 100 and 50 per cent respectively.

It is interesting to note further that while the per capita increase in gross annual revenue, of the privately owned works (see table 10) was about 56 per cent, that of the publicly owned works was but about 33 per cent. This grows out of several causes most important of which are the smaller revenue required by publicly owned works because of their freedom from taxation, which in the case of the privately owned works has doubled in this period, and because the burden of interest or fixed charges is generally less in the municipally

owned works by reason of the lower interest rate[4] and past amortization of debt and in some cases the fact that the works are not self-sustaining, but receive revenue from the general tax levy or assistance through the assessment of real estate or the water taker, for the distribution pipe system.

Operating expenses increased rapidly after the year 1916, to the peak in 1923, when these expenses were about 127 per cent, or 2¼ times the operating expense of prewar days, as shown in table 9

TABLE 10

Average per capita revenue and operating expenses of privately and publicly owned water works, for 1915 and 1923

(Determined by averaging the per capita records of the individual works)

	Group A—Privately owned (32 cities)			Group B—Publicly owned (11 cities*)			Groups A and B (43 cities)		
	1915	1923	Per cent increase	1915†	1923	Per cent increase	1915†	1923	Per cent increase
Gross annual revenue	$3.55	$5.54	56	$2.95	$3.92	33	$3.40	$5.13	51
Operating expenses, excluding taxes and depreciation	1.15	2.30	100	1.32	1.80	36	1.19	2.17	82
Operating expenses, including taxes and excluding depreciation	1.45	2.94	103	1.37	1.81	32	1.43	2.65	85
Operating revenue after deducting taxes	2.10	2.60	24	1.58	2.11	34	1.97	2.48	26
Depreciation		0.30			‡			(0.37§)	
Net revenue		2.30			‡			(2.17§)	

* Includes Denver, Colorado, which was privately owned in 1915.

† Data for Philadelphia, Pa., is for 1916.

‡ Average for the 6 cities making depreciation allowance—depreciation 74 cents; net revenue $1.48.

§ For 38 cities.

and figure 2. In the operating expenses herein referred to are included operating and maintenance expenses and taxes—but not depreciation allowance.

In table 10 the same data are shown on per capita basis, reflecting the effect of growth in population during this eight-year period.

[4] Due to the facts that municipal bonds are usually secured on the credit of the municipality rather than on the water works property only, and the exemption of municipal bonds from Federal taxation.

In this table the operating and maintenance expenses have been shown first exclusive of taxes and depreciation; second, including taxes and excluding depreciation; and the depreciation allowance has been separately shown for the year 1923, the record for the year 1915 being too fragmentary to be of significance. As previously stated, however, it is estimated that the average depreciation allowance for the year 1915 was probably less than 25 cents per capita. The records cover separately the privately and publicly owned works and all of the works combined.

On the per capita basis it will be observed that the increase in operating expenses was over 80 per cent—about 100 per cent for the privately owned works, 36 per cent for the publicly, and 82 per cent for the combined works.

Bearing in mind the fact that the increase in population served by these works during this eight-year period was about 28 per cent or 3.1 per cent compounded annually, and that some advance in cost of operation is always observed, it is probably fair to say that the normal increase in operation cost of these works would have been about 5 per cent compounded annually, aggregating nearly 50 per cent (47.7 per cent) in an eight-year period. Under such circumstances the abnormal increases in operating and maintenance expenses and taxes, were about as follows in gross percentage:

	per cent
Increase due to 28 per cent increase in population in eight-year period (1915–1923)	25
Increase upon old (1915) population	25
Increase by growth (equivalent to 5 per cent compounded annually)	50
Abnormal increase due to war	75
(Total) increase in gross amount	125

and the increases on per capita basis,

	per cent
Normal increase	25
Abnormal increase due to war	75
(Total) increase on per capita basis	100

The abnormal increase due to the war, then, has been about 75 per cent in excess of prewar conditions, exemplified by those of the year 1915.

The increase in taxation has been very burdensome, averaging somewhat over 100 per cent. In other words, the taxes paid by the

water works of the country are today more than double the amount paid in 1915. In the privately owned works the increase has been from about 30 to 64 cents per capita and, if there be omitted from the record the Pennsylvania works, the corporate taxes upon which are very light by comparison with those of other states, the increase in taxation upon the other privately owned works is found to be from about 37 to 77 cents per capita, five companies now paying between $1.04 and $1.30 per capita for taxes. It is believed that, taken as a whole, the privately owned water works of this country are paying on a substantially higher basis of valuation than are other public service corporations serving the same communities or than is private property in these communities. These works probably felt the influence of the old doctrine "What the traffic will bear," because taken as a whole the water works of the country, serious as their situation has been, have not felt the effect of the war increases so seriously as have the railroad, gas, electric and telephone companies, though it is probably true that the readjustment in rates has been more rapid and effective in the case of the telephone and gas companies than it has been in the case of the water works, the electric and the railroad companies.

The net annual revenue applicable to depreciation and return, or to depreciation, interest, dividends and surplus, is shown in table 9 and figure 2.

It increased from 1915 very slowly, to about 10 per cent in the year 1920, after which the effect of the increase in rates granted by the commissions and courts began to make itself felt. The average net revenues recorded for these works reached a maximum increase in 1923 of about 57 per cent over prewar (1915) basis. Further substantial increase has taken place within the year 1924, and will doubtless be felt within the next few years, as indicated hereinafter.

On the per capita basis (table 10) we find the increase in net annual revenue applicable to depreciation and return but 24 per cent for the privately owned works and 34 per cent for the publicly owned works, or 26 per cent for all the works reporting.

The gross increase of 57 per cent may be divided as follows:

	per cent
Increase due to 28 per cent increase in population (1915–1923)...	20
Normal increase upon old (1915) population....................	17
Increase by growth (4 per cent compounded annually)...........	37
Increase due to increase in rates..................................	20
Gross increase (in operating and maintenance expenses and taxes)...	57

On a per capita basis we should expect to find:

	per cent
Normal increase about	20
Increase due to increase in rates	20
Total per capita increase	40

but as a matter of fact we find a total per capita increase of but 26 per cent. This is due to the effect of the abnormal increase in operating and maintenance expenses and taxes of about 75 per cent. Bearing in mind that for gravity works the operating and maintenance expenses and taxes are about 25 per cent of gross annual revenue; for plants having to pump and filter the water, 45 per cent; and for these works as a whole perhaps 40 per cent; the effect of this 75 per cent increase in operating expenses, in terms of net revenue applicable to depreciation and return would be 75 per cent × 40 per cent = 30 per cent of gross annual revenue, and 75 per cent × 40 per cent × 60 per cent = 18 per cent of net annual revenue applicable to depreciation and return. Hence the 40 per cent anticipated increase on per capita basis would be reduced by 18 per cent and leave a net increase of about 22 per cent, which is substantially what the records give, 26 per cent.

Otherwise expressed, of the 40 per cent increase in net annual operating revenue per capita which one would normally expect with 20 per cent increase in water rates and 17 per cent to 20 per cent increase in business in an eight-year period, 18 per cent has been wiped out by the abnormal increase in operating and maintenance expenses and taxes due to the war, and the 20 per cent per capita increase due to increase in water rates (during this eight-year period) only is left.

As of the end of the year 1923, then, the net revenue of these plants, was about 20 per cent above prewar basis. This is comparable with the 100 per cent advance in water works labor and material costs, and the 50 per cent advance in general commodities.

CONCLUSION

Speaking in general terms, the water works of this country are past the period of acute distress, due to the war. The rate increases granted by commissions and courts have enabled them to recover earning power to a point probably not over one-fifth (20 per cent) above prewar basis. As this basis is, however, far below the actual plane of costs and values during this eight-year period (1915–1923)

TABLE 11

Privately owned works. Per capita records

	1915 RECORDS	1923 RECORDS	NECESSARY PREWAR BASIS* FOR 7 PER CENT RETURN	NECESSARY POSTWAR BASIS TO EARN 7 PER CENT RETURN WITH ADVANCE IN WATER WORKS VALUES OF	
				50 per cent	100 per cent
1. Value or property (estimated), dollars	35.00	35.00 (Prewar)	35.00	52.50	70.00
2. Gross annual revenue, dollars	3.55	5.54	4.25	7.12	8.54
3. Operation, dollars	1.15	2.30	1.15	2.30	2.30
4. Taxes,* dollars	.30	.64	.30*	.64	.64
5. Net operating revenue, dollars	2.10	2.60	2.80	4.18	5.60
6. Depreciation allowance, dollars	.25	.30	.35	.50	.70
7. Net divisible revenue or net return, dollars	1.85	2.30	2.45	3.68	4.90
8. Rate of return, per cent	5.3	6.6	7	7	7
9. On basis	Prewar	Prewar	Prewar	Postwar	Postwar
10. Necessary increase in gross annual revenue over 1923 records, per cent				28	54

* Penn sylvania Companies' corporation taxes are relatively very much lower than in most other states. Thus:

Average taxes per capita paid:

	In 1915 *cents*	In 1923 *cents*
By 8 Pennsylvania Companies	11	24
By 24 Companies in other States	37	77
Average 32 companies	30	64

these works have not been able to earn anything like the legal fair return upon the fair value of their properties, nor does it appear probable that this loss which has been estimated as substantially in excess of the sum of $250,000,000, will ever be made good. This loss was their contribution to the fighting of the Great War, and gives point to the undoubted fact that in times of serious crisis the commissions cannot give fair rate of return to such properties, and therefore do not in fact remove the hazards of operation from them, as has often been asserted.

At present the average rate of return is probably about 20 per cent in excess of prewar basis, whereas the general advance in commodity prices has been shown to be about 50 per cent, and in the water works field 100 per cent; and values are undoubtedly approximating these higher planes of cost.

In table 11 are shown, for the privately owned works of this country, the approximate gross annual revenues of record in the years 1915 and 1923; the return which would have been necessary to earn a 7 per cent rate under prewar basis (1915) and will probably be necessary to earn a 7 per cent return under postwar conditions, with a normal advance in value of water works of 50 per cent and of 100 per cent.

An average value of water works property for this country of $35 per capita under prewar conditions—which was fairly characteristic of the northeast, slightly high for the south and low for the semi-arid and arid western states—has been assumed.

Upon this basis the recorded average gross annual prewar revenue (for the year 1915) of $3.55, equivalent to 10 per cent on value, yielded a divisible net annual return of $1.85, or about 5.3 per cent upon fair value. This rate is comparable with allowances by the courts and commissions of 7 per cent or more.

Similarly for the postwar year 1923 the recorded gross annual revenue of $5.54 yielded a divisible return of $2.30, or 6.6 per cent on prewar, not on postwar, value.

To have earned a 7 per cent rate of return on prewar basis these privately owned works should have had in 1915 an average gross annual revenue of $4.25, instead of $3.55.

On postwar value basis 50 per cent in excess of prewar, giving an assumed average per capita value of these works of $52.50, the necessary gross annual revenue to earn a 7 per cent divisible net return would have to be $7.12, instead of the recorded average for 1923 of $5.54—involving *an increase of about 30 per cent.*

Similarly, if the postwar basis of value of water works be assumed to be 100 per cent in excess of prewar basis, as are the general costs of water works materials and labor, the necessary gross annual revenue to yield a 7 per cent divisible net annual return would be $8.54 per capita, instead of $5.54 recorded for the year 1923. This would involve *an increase of about 50 per cent.*

It may fairly be anticipated, then, that under average conditions there will be an advance in water rates of at least one-third in the next few years, if water works values are readjusted in conformity with those of other property.

The postwar financial problem of the water works of the United States has clearly not yet been solved. There is good ground however, for hope of further relief in the recent decisions of the higher courts of this country, which have made clear that postwar, rather than prewar conditions, and present value rather than original cost, must control in public utility rating problems as in other economic fields. This increase in value, due largely to the loss in purchasing power of money, coupled with the general advance in the fair rate of return now and hereafter to be enjoyed by these works, as compared with the actual average prewar rate, will justify increases in rates which improving business conditions will make possible.

Marked progress has been made in making good the postponed betterments of the war period, replenishing the margins of safety, and bringing these properties to a higher degree of perfection.

Good service from its water works is so essential to the health and industrial success of the public that a period of prosperity to these works may reasonably be expected, if their managers are persistent in their efforts to obtain fair recognition of the difficulties under which they still labor.

PROTECTION OF PUBLIC WATER SUPPLY BY FOREST COVER[1]

By W. W. Ashe[2]

Forests may be employed in several ways in promoting the protection of potable water supplies. The most important ways, however, in which forests may function are in the protection of catchment areas and in the protection of reservoirs and settling basins. The employment of such means in no way, however, obviates the necessity of filtration or minimizes the requirement for sanitation. A reservoir having its surrounding slopes protected by forests may enable water of a lower turbidity to be delivered, and a forest cover may also prolong the life and value of a reservoir. The forest covered catchment area may insure the receipt at the filter of water of lower bacterial count, as well as of lower turbidity. There will be many cases where the revenue which may be secured from a well managed forest on a catchment area will be a material contribution toward meeting its cost.

INFLUENCE OF SOILS

It is not intended to imply that the protection afforded by a forest cover is of equal value on all sites. The solid burden of streams which have their sources within regions of sandy or gravelly soils is relatively low. Such regions are the coastal region of the southeastern states, northern New England, New York and the Great Lakes region. It is frequently the case, however, that streams flowing through such sandy regions are discolored by the leachings of humus and other plant matter. Some of the streams of the coastal plain, especially in the sandy, hilly sections, are of crystal clearness and have a pellucidity which is unaffected by heavy storms. These sandy soils have high water storage capacity and great steadiness of stream flow.

On the other hand, many of the clay soils, particularly those of the Piedmont of the southeastern and Gulf States, have a high con-

[1] Presented before the North Carolina Section meeting, November 12, 1924.

[2] United States Forest Reserve, Washington, D. C.

tent of clay of colloidal fineness. Colloidal material of this kind settles slowly even in still water and is the principal cause of the prevailingly muddy streams of the Piedmont region of the southeastern states. On account of this colloidal clay a most moderate rain often causes excessive erosion from naked soils and results in a great increase in turbidity. Such clayey soils likewise have a lower absorptive capacity than sands and loams and more easily lose their granulation, and it is the surface granulation of a soil which determines its initial capacity to absorb rainfall. Heavy clays also have a lower water storage capacity. The result of these conditions throughout the Piedmont of the southeastern states and in similar regions of clayey soil elsewhere is short periods of very high and muddy water following storms, and often long periods during which the flow of the streams may be low though seldom entirely clear. This situation is trying on a water supply system and the cry of "shortage" is a familiar one during the late summer and autumn periods. It is evident consequently that the influence of the character of the soil is paramount in determining the regularity of stream flow and the amount of turbidity.

INFLUENCE OF FOREST COVER ON EROSION OF SOIL

The value of the forest cover then as a means of protecting a soil against erosion varies. On very sandy sites, whether the terrain is level or hilly, the protective functions of forest cover are of low value. Storm water is readily absorbed by such soils for the granulation of a sand is a constant feature. The forest cover, however, exerts a high protective influence upon clay and clayey soils, especially upon such as contain a considerable colloidal content and upon such as are subject upon denudation to excessive erosion during storms. The forest humus and the admixture of humus in the soil tends to maintain granulation of clayey soils and in this way to promote absorption of heavy rainfall. The many small channels in the soil, caused by the decay of roots, likewise promote absorption, especially in the lower soil and subsoil. The carpet of litter and leaves beneath the forest receives the impact of raindrops and such water as is not absorbed by the surface soil largely runs off over this litter in place of over naked soil. The more broken the surface, the steeper the gradient, and the longer the slope the greater is the protective value of the forest cover. Likewise the depth of the accumulation of leaves and litter is im-

portant, and forests which are burned and the litter beneath which has been destroyed, or reduced in thickness by fire or by excessive grazing, are less effective in affording protection to the soil than such as are in normal condition. As to how far the forest cover may be influential in equalizing stream flow is still in most regions an open question, but there is little doubt that as a rule more storm water is absorbed by clayey lands when in forest cover than either by cleared land or by land in grass, and consequently on clayey sites there is a tendency for springs to fail when forest conditions no longer exist. On the whole, this greater regularity more than compensates for the moisture removed from the soil by the trees of the forest in their physiological processes.

FORESTED CATCHMENT AREAS

When a corporation owns the basin from which it derives its supply of potable water it can largely prevent its pollution and can secure at the filter a water the purity of which is further safeguarded by filtration. The high cost of acquiring entire watersheds frequently deters a municipality from such a purchase. It is true that New York City owns its watershed; but it was costly. The City of Asheville, in North Carolina, has acquired the entire basins from which it at present draws its supply, but unfortunately the City failed to look far ahead and its provision for a supply is already regarded as inadequate for its early future needs. It is believed that, if towns, especially within and near the mountains, fully realized the investment possibilities of forested watersheds, purely from a timber producing standpoint, more of them might follow the example of the City of Asheville and a score of others and seek to own the catchment basins from which their supply is furnished. The point may be raised that if a town owns such a watershed the timber cannot be used; or if used the watershed is open to the same forms of contamination as if in the hands of a number of private owners. This is not necessarily the case, for the town can so regulate the manner and time of the removal of the timber as to interfere but little with the regimen of the stream; can manage so as to protect its clearness and safeguard its purity. No broad statement can be made as to the investmental value of such forest land or conditions under which purchases would be advisable. But it can be said that the values of such properties, if acquired at current market prices and if the potentialities as forest investments are carefully

considered, are still low and that at least such cities or towns as are near suitable watersheds which are largely forested could well consider such a course. It is further believed that the time will come, and it is not so far off, when such forested watersheds, even though used as sources of municipal water supply, can likewise be employed under restrictions for recreational purposes.

PROTECTION OF RESERVOIRS

In addition to the sanitation and increased value of a water of lower turbidity, the loss in storage capacity in reservoirs through silting up is a condition which sometimes demands consideration. Where silt can be cheaply removed from a reservoir this subject is not important. When silt, however, cannot be removed, it may at times be desirable, especially in cases when the larger amount of the silt which is being deposited comes from a limited, rugged or poorly farmed area, to consider the purchase of this land and the planting of it to trees; or in case the land is already owned by the corporation then the advisability of its planting can be taken up. On one hand, there will be the cost of acquiring such land and the establishment of forests on those portions which demand such protection. This cost will be offset by the lengthened life of the reservoir, due to the lowered turbidity of the effluent and reduced sedimentation and by the income from the sale of timber grown on such land.

At times it may also be profitable to plant trees to unused, open lands, especially slopes immediately around reservoirs, even when erosion from these lands is not a serious menace. This should be done for the purpose of making each part of the investment produce some income or be of some service. It will be necessary in such a case to consider a choice of species for planting, selecting those kinds which are best suited to the soil and moisture conditions, as well as the rate of growth of the kind which is employed and the possible returns which may be secured from the sale of this timber.

A further consideration which may warrant attention at times is the protection of reservoirs against wind influence. The finer material which occasions most of the turbidity settles in reservoirs very slowly. Sedimentation usually proceeds with a certain expected uniformity, a high percentage of turbidity being eliminated from water of a high turbidity and a smaller percentage from that of a lower turbidity, owing to the slower settling of the finer par-

ticles which cause the low turbidity. The greater proportion of clarification in water of high turbidity is suggested by Mason as being due to the well-known tendency of larger falling particles to drag down with them very fine particles, and even matter in solution. The subsiding, heavier silt drags down not only much of the finest clay, but bacteria as well. It is important, therefore, that the first sedimentation be as thorough and uninterrupted as possible, since after the settling of the heavier particles the finer material which is left, having failed to be carried down by the coarse material, remains in suspension a great while and is with difficulty eliminated from the water by further sedimentation. Only a certain proportion of it is removed by filtration, and it follows that the lower the turbidity of the water as it goes to the filter beds the clearer the effluent.

At different times, but usually during the winter and spring, on account of wave action produced by wind, sedimentation in the reservoirs not only takes place very slowly and irregularly or not at all, but additional turbidity is acquired by the water from the scouring of the sides or, at shallow places, the bottoms of the reservoirs, a portion of the thin coating of silt and clay that has previously been deposited being again taken up in suspension. With this increase in turbidity a portion of the recently deposited bacteria are also redistributed through the water.

During the winter and spring, moreover, when the temperature of the water is about the same throughout, constant wind action, though light, from any one direction, will easily cause a complete overturning of the water in the reservoir.

The period of wind agitation of water in small lakes and reservoirs, as has been pointed out by Birge, is largely limited to the winter and early spring months, after the water has become homothermous. During the summer and early fall the temperature of the surface water becomes much higher than that of the water at the bottom of the reservoir, and the surface water is consequently much lighter, there being a warm, superficial stratum of water, the colder bottom stratum, and a thin stratum between them in which the temperature rapidly falls, called by Birge the thermocline.

In order to lessen[3] such wind action the planting of wind breaks of trees around the edges of reservoirs is recommended; as well as

[3] For a further discussion of this subject see article by the writer in Water Supply and Irrigation Paper No. 192, U. S. Geological Survey, p. 329.

the separation of long reservoirs greatly exposed to wind action into two or more segments and the planting of trees along the separating embankments.

In conclusion it may be said that the value of forest cover in protecting municipal water supply depends upon the soil and site. The employment of this means involves several phases and it has seemed preferable at the present meeting to discuss briefly the general subject and the limitations of forests in affording protection rather than to consider a special phase.

DISCUSSION

C. G. Logan:[4] In reference to my water shed, I found if we turned the shed loose and fenced it in one year we could not get through it. It just naturally grows up and gets to be a regular lion's den. We have not gone so far as to plant trees for revenue. We only have about 3400 acres in our shed, but I know our first shed has been fenced about thirteen years and we get more water out of it now. It ran our town this summer all but four days. We only had to draw on our new shed for four days for part of our supply, and before that was fenced up, when there was opposition to buying it, the doctors came before the Board and said there was not enough water for the horses to drink when they went in that country to visit their patients, and this one stream has now been supplying Waynesville, Junaluska and Hazelwood. That will show you how forests will cause the water to stay there and come out gradually. Like a regulator on an effluent line, it lets it come out gradually when you need it.

Thorndike Saville:[5] Mr. Ashe is one of the few professional foresters I have heard talk who does not make enthusiastic claims as to the possibility of the forests in increasing the run-off, but is more conservative. I think Mr. Logan has hit the mark. It does not increase the total run-off, but it does unquestionably regulate that run-off, which is after all what we are most interested in. That is undoubtedly one of the peculiar benefits aside from the very material benefit of reducing the silting. In the north they have used these municipal water shed forests for another purpose. They have not only sold timber from them, which is about enough to

[4] Superintendent, Water Works, Waynesville, N. C.

[5] Associate Professor, Hydraulic and Sanitary Engineering, University of North Carolina, Chapel Hill, N. C.

carry the operating expense, but they also serve to keep their pipe-laying gangs employed during the winter. Of course, they have much more severe winters there, and they can in this way keep their gangs together by using them in the forests cutting wood and stacking it, and in that way the forests serve still another purpose.

A. O. TRUE:[6] At the plant of the Proximity Manufacturing Company we draw our water from a very small water shed, about 2¾ square miles, but I think we are getting a tremendous yield from that. I have been over pretty much all of it myself, and I estimate that it is 90 per cent forested. We have no large streams, they are all small surface streams that are feeding this reservoir—springs—and we are taking out of it I estimate an average of two million gallons a day. We have only been running there for two and one-half years so that we cannot tell you very much about the deficiency of water in that reservoir. I think the first year we operated we got the reservoir down during the dryest season to a point about 5 feet below the spillway. The second season we operated it was not down more than 3 feet and this year, in which we have had exceptional rainfalls, the minimum level in the reservoir has been a little over a foot, so that I feel that this question of foresting the area plays a very important part in yield of a reservoir, because this particular watershed seems to be yielding a very large amount of water and I attribute it to the fact that we have a large amount of forestation on it.

[6] Sanitary Engineer, Proximity Manufacturing Company, Greensboro, N. C.

THE DESIGN OF WASH WATER TROUGHS FOR RAPID SAND FILTERS

By Milton F. Stein[1]

Inspection of plans for rapid sand filter plants, and of the operation of completed plants, indicates considerable variation in the proportions of the wash water troughs. Quite often these are made too large, and therefore interfere with the distribution and functioning of the wash water to some extent. Sometimes they are too small to carry off the wash water. As one of the few visible evidences of the hydraulic design of the plant, it is a matter of satisfaction to the engineer when these are correctly proportioned, with neither excess nor deficiency of capacity.

It is not difficult to write the differential equation[2] of flow for a wash water trough, but the integration of the resulting equation in a practicable form seems to be impossible. This is due entirely to the friction term of the equation, and suggests that either the form in which these troughs are built is not in conformity with the theoretical requirements, or else that there are defects in our conceptions of fluid friction losses. While the exact solution of the problem is therefor of interest to the pure hydraulician, it is a fact that a sufficiently good practical solution can be obtained by approximating the refractory friction term, since for all ordinary sizes and proportions of troughs, this term is small as compared with the total losses which govern the equation of flow.

Referring to figure 1, which represents a trough with parallel sides, but without restriction as to the shape of bottom, and wherein:

A = the total available cross-sectional area
P = the corresponding wetted perimeter
y = the surface drop due to various losses
b = the width between parallel sides

[1] Civil Engineer, Chicago, Ill.

[2] The differential equation in question is, as follows:

$$\left(y^3 - \frac{q^2x^2}{gb^2}\right) dy + \left(\frac{q^2xy}{gb^2} - \frac{fq^2x^2y}{gb^3} - \frac{fq^2x^2}{2gb^2}\right)dx = 0$$

l = the length
q = the water entering per unit of length, x, so that ql =
Q = the total flow or capacity of the trough
h = the head lost in friction
f = the coefficient of friction, assumed as 0.01 (the usual value for cast iron pipe is around 0.005)

the effect of friction being neglected, and also the drop due to overfall at the outlet end of the trough (shown dotted):

The loss of head, due entirely to the velocity acquired is

$$y = \frac{Q^2}{2g\,(A - by)^2}$$

from which it follows that the discharge is

$$Q = \sqrt{2g}\,(Ay^{\frac{1}{2}} - by^{\frac{3}{2}})$$

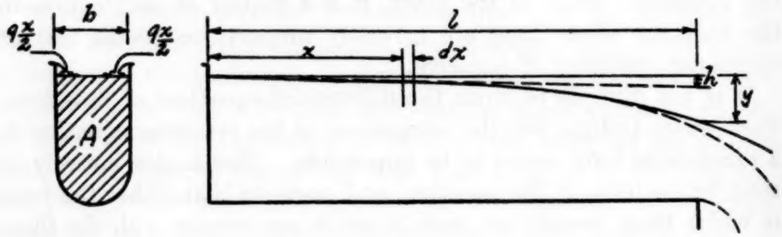

FIG. 1

Differentiating with respect to Q and y, to obtain the condition of maximum discharge, there results

$$Q = \frac{2}{3}A\sqrt{2g\cdot\frac{A}{3b}} \qquad \text{I}$$

When the effect of friction, assumed to be h, is taken into account, the loss of head may be written

$$y - h = \frac{Q^2}{2g\,(A - by)^2}$$

and following through in the same manner as for equation I, there is obtained

$$Q = \frac{2}{3}(A - bh)\sqrt{2g\left(\frac{A}{3b} - \frac{h}{3}\right)} \qquad \text{II}$$

For an increment of length, dx, the friction loss may be written

$$dh = \frac{f\,q^2\,x^2}{2g\,(A - by)^3}\,(P - 2y)\,dx$$

The difficulty in integrating this lies in the unknown relationship of x and y, due to the inability of integrating the fundamental differential equation as already mentioned. Treating this as a partial in x, on integrating gives

$$h = \frac{f\,l}{3}\left(\frac{P - 2y}{A - by}\right)\cdot\frac{Q^2}{2g\,(A - by)^2} \qquad \text{III}$$

which would be correct if the smallest cross-section of flow, A-by, obtained throughout, and is evidently a maximum result.

For all ordinary proportions and lengths of wash water troughs the friction loss is quite small, usually less than 12 per cent of the velocity head, so that generally an approximation on this basis is close enough, or modifying formula I,

$$Q = 2.8\,A\sqrt{\frac{A}{b}}\ \text{(approximate)} \qquad \text{IV}$$

If greater accuracy is desired, then a closer approximation of formula III can be made by assuming an average value for the hydraulic radius, or P-y for the wetted perimeter, and A-$\frac{1}{2}\,by$ as the corresponding area; or

$$h = \frac{1}{4}\frac{f\,l\,Q^2}{gb\,A^3}\,(3\,Pb - A)\ \text{(approximate)} \qquad \text{V}$$

and substituting this value in formula II.

As an example the capacity of the trough shown in figure 2 will be computed. First using the approximate formula IV.

$$A = 1.7 \text{ square feet}$$
$$b = 1.16 \text{ feet}$$
$$A/b = 1.45 \text{ feet}$$
$$Q = 2.8 \times 1.7 \times (1.45)^{\frac{1}{2}} = 5.75 \text{ second feet} = 2590 \text{ g.p.m.}$$

Using this value of Q in formula V,

$$h = \frac{1}{4}\cdot\frac{0.01 \times 14.8 \times 5.75^2}{32.2 \times 1.16 \times (1.7)^3}\,(3 \times 3.82 \times 1.16 - 1.7) = 0.076 \text{ feet}$$

and substituting this value of h in formula II, there is obtained:

$$A - bh = 1.7 - 0.076 \times 1.16 = 1.61; \frac{A}{3b} - \frac{h}{3} = 0.48 - \frac{0.076}{3} = 0.45$$

$$Q = \frac{2}{3} \times 1.61 \sqrt{2g \times 0.45} = 5.75 \text{ sec. ft.}$$

which is in substantial agreement with the first result.

For various reasons the writer favors the deep, round-bottomed trough of uniform section throughout, and made of steel plate. It is the most easily fabricated, and if well protected in the first place by means of rust resisting paint will last almost indefinitely; besides which they can be so designed as to be readily replaceable without disturbing the concrete work of the filter. Inspection of

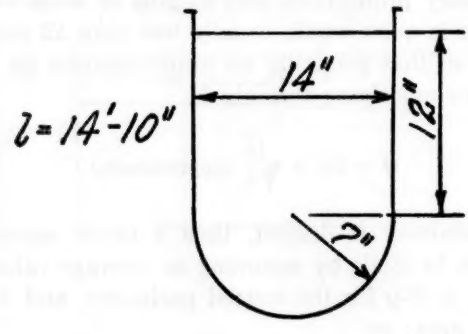

FIG. 2

the various formulae shows that the capacity for a given area increases as b decreases, that is, as the trough is made narrower, which holds within all reasonable limits to be met with in design. Sloping or tapering the trough does not improve it hydraulically, in fact slightly decreases the capacity due to the increased friction loss. Furthermore, if the trough is of uniform section throughout, its effect on the distribution and velocity of the wash water is constant over the whole area of the filter. Since it is impossible to have the troughs so shallow as to be above the top of the sand blanket while washing, it is as well to make them narrow and deep, and make proper allowance for such restriction as they cause by increasing the freeboard. But probably the most important point in favor of the deep round-bottomed trough is that it parts the water smoothly

and without deflection, and at such a depth beneath the surface that the water has ample opportunity to assume its natural stream-line flow before reaching the surface, so that the transporting of the sediment is not disturbed by counter currents. With a shallow trough, flat-bottomed or V-bottomed, on the other hand, the deflection of the rising water is outward from the trough, creating strong counter currents which directly oppose the desired surface flow toward the trough. The only objection to concrete troughs, aside from their usually undesirable shape, and often rough workmanship, is that due to their thickness, they cause needless obstruction of the flow area.

DISCUSSION

Clifford N. Miller:[3] The writer was particularly interested in Mr. M. F. Stein's paper as he, also, has worked out an approximate formula for the discharging capacity of a wash water trough. He offers the following comments on the mathematical part of the paper.

In the equation,

$$y = \frac{Q^2}{2g(A - by)^2}$$

all the energy acquired by the water in falling from the edges of the trough is assumed to appear in the velocity head at the outlet. It seems to the writer, as more in accordance with the facts, to assume that the energy, acquired in falling from the edges of the trough to the surface of the water flowing in the trough, is dissipated in generating heat and in forming eddies or whirls. From this point of view the velocity head at the outlet would be the average fall of the water surface, which may be put equal to *my*, *m* being a coefficient dependent upon the form of the water surface. Instead of the above equation we would have then,

$$my = \frac{Q^2}{2g(A - by)^2},$$

whence

$$Q = \sqrt{2gm}(Ay^{\frac{1}{2}} - by^{\frac{3}{2}})$$

[3] Consulting Engineer, Cincinnati, Ohio.

By differentiating with respect to Q and y, to obtain the maximum discharge, we have

$$Q = \frac{2}{3} A \sqrt{\frac{2gm\, A}{3b}}$$

If equation III,

$$h = \frac{f\,l}{3}\left(\frac{P - 2y}{A - by}\right) \frac{Q^2}{2g(A - by)^2}$$

be applied to the case of the trough, shown in figures 1 and 2, the factor $\frac{P-2y}{A-by}$ has the value 2.25 when y equals O and the value 2.53 when $y = \frac{A}{3b}$ (the value of y for a maximum value of Q, no friction). It would seem a close enough approximation for practical purposes and also in accord with the assumption made in obtaining equation IV, to put

$$h = \zeta \frac{Q^2}{2g(A - by)^2}$$

In the equation

$$y - h = \frac{Q^2}{2g(A - by)^2}$$

put my for y and the above value for h and we have

$$my = (1 + \zeta) \frac{Q^2}{2g(A - by)^2},$$

whence

$$Q = \sqrt{\frac{2gmy}{1 + \zeta}}\, (A - by)$$

By differentiation with respect to Q and y, to obtain the maximum discharge, we have

$$Q = \frac{2}{3} A \sqrt{\frac{A}{3b} \cdot \frac{2gm}{1 + \zeta}}$$

The approximate formula, worked out by the writer (see equation 9, in appendix B of Mr. J. W. Ellms' book on "Water Purification"), is

$$Q_1 = \sqrt{\frac{8}{27} \cdot \frac{mg}{1 + \zeta}}\, b(y_1 + l \tan \alpha)^{\frac{3}{2}}$$

in which

Q_1 is the discharge (Q in Mr. Stein's paper)
m and ζ are coefficients as above
y_1 is the depth of water in the upper end of the equivalent rectangular trough (equals A/b in Mr. Stein's nomenclature)
α is the slope of the bottom (equals 0 in the trough assumed by Mr. Stein)

By making the proper changes in this equation, to suit Mr. Stein's case and nomenclature, we have, again,

$$Q = \frac{2}{3} A \sqrt{\frac{A}{3b} \cdot \frac{2gm}{1 + \zeta}}$$

In this equation put $m = \frac{2}{3}$ (i.e., assume the surface curve to be a parabola) and $\zeta = 0.12$ (as assumed by Mr. Stein) and we have,

$$Q = 2.38\, A \sqrt{\frac{A}{b}}$$

which gives a discharge for the trough, shown by figures 1 and 2, of

$$Q = 2.38 \times 1.7 \times \sqrt{\frac{1.7}{1.16}} = 4.9 \text{ c.f. per sec.}$$

which is as much or more than the writer would take for the capacity, in design.

MINIMUM REQUIREMENTS FOR PLUMBING IN DWELLINGS AND SIMILAR BUILDINGS[1]

By Albert L. Webster[2]

I have been asked to call your attention to a recent publication issued by the United States Department of Commerce (in its "Elimination of Waste Series") entitled *"Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings."*

This is the report of a sub-committee on Plumbing of the Building Code Committee, called together by Secretary Hoover, in an effort to unify and standardize the building codes of the country.

Dr. George C. Whipple, late Professor of Sanitary Engineering at Harvard, was the Chairman and guiding spirit of the Plumbing Committee, and it was the intention to have him address you today on the subject of the report.

His untimely and lamented death last November frustrated this intention, and I have been asked to take his place.

It is with the utmost diffidence that I consent to do so. It is only in affectionate appreciation of his memory and with the desire to broadcast the results of his last, admirable work of public devotion that induces me to speak in his place.

This gathering of accomplished engineers, specialized in the larger fields of water supply, sewerage and sanitation. This galaxy of talent may ask: Why a report on the ridiculed and neglected subject of plumbing should be presented for your serious consideration.

I can perhaps best answer that inquiry by quoting a paragraphs from the Report.

> The work of the committee has emphasized the necessity of considering the plumbing systems of buildings as intimately related to and forming an integral part of public water-supply and sewerage systems. The number and character of plumbing fixtures in a building are largely matters of individual choice, and owners have not sufficiently considered their relation to features of public

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[1] Presented before the Joint Meeting of the New York Section, American Water Works Association, and the Sanitary Engineering Division, American Society of Civil Engineers, New York, January 22, 1925.

[2] Consulting Engineer, New York, N. Y.

service. Plumbing fixtures are the terminals of water-supply systems, and, to a large extent, control the quantity of water used. At the same time they are the beginnings of the sewerage system. The aggregate discharges from plumbing fixtures determine the flow in sewers and the volume of sewage reaching the outfall, this volume materially affecting the cost of any pumping or treatment of the sewage. It is evident, therefore, that the public interest may well justify a certain degree of governmental control over plumbing fixtures as affecting both the quantity of water available for public use and the economical operation of the sewerage system. . . . .

Although the American people have expended hundreds of millions of dollars for plumbing installations, the principles of their general layout have never been thoroughly understood. Actual practice has been governed by opinions and guess-work, often involving needless costly precautions which many families could ill afford. The lack of generally recognized principles is responsible to a certain extent for the contradictory plumbing regulations in different localities.

Thanks to the work of the subcommittee and of the Bureau of Standards, the whole situation is altered, and there is now a scientific basis upon which State and local codes and small-dwelling installations may be based.

To further emphasize the interrelation of plumbing with the public utilities designed to serve it, I would call your attention to the significance of new conditions in large cities, arising from the erection, in recent years, of the mammoth buildings designed for business, apartment, hotel and hospital uses.

The features of plumbing in these buildings are quite worthy of the attention and study of accomplished engineers.

The Equitable building in this city has a fixed population during office hours of from 8000 to 10,000 people—125,000 people pass daily through the main hall. Every working day in the year about 450,000 gallons of water goes into the building and the bulk of it in turn flows out to the public sewer.

The building covers approximately an acre of ground; and if enough of these buildings were put up one square mile of superficial area would give accommodation to five million of people, or more than the entire population of Manhattan and Brooklyn.

This building, in which we sit and eat the delicious and inexpensive food set before us, has a more or less permanent *guest* population of 2600 people on ¾ acres of land. Nine hundred thousand gallons of water a day flow through it in the plumbing pipes. There are two thousand fully equipped bathrooms, besides two Turkish Baths able and willing to scrub, wash and rinse sixty people an hour. There is a laundry under its roof, equipped to launder and turn out one hundred thousand flat pieces a day.

The stigma of "The Great Unwashed" can never be attached to a guest of this hotel. In fact, it might even be said that he is over-washed or super-washed. The thought of the intensive bathing that takes place under this roof on Saturday nights is staggering to the imagination. All of this attempt at airy introduction is intended to emphasize the fact that these buildings may be likened to a town of considerable size that has been compressed, condensed and turned up on end; where the water mains and sewer tentacles rear their lengths vertically instead of lying peacefully underground. So I say to you gentlemen, "When your interest stops at the curb line you have not finished your job."

The steps that led to the creation of the Plumbing Committee were briefly as follows:

In 1920 the United States Senate Committee on Reconstruction and Production directed its attention to the then prevalent inactivity in the building industry; among other reasons for that condition it suggested that the great variance in the requirements of building codes, in different parts of the country, probably had an influence in retarding building construction.

Secretary Hoover of the Department of Commerce, ever keen for standardization, created a "Division of Building and Housing" in his Department and invited a group of well known experts to serve as a volunteer committee to examine and report on the unification of the building codes of the country, with special attention to the needs of small dwellings (one and two family houses). Mr. Ira H. Woolson, Consulting Engineer of the National Board of Fire Underwriters, was chairman of this committee.

They found strange and weird differences in the structural requirements in different parts of the country. By way of illustration we may say that an eight inch brick wall in Boston, under fixed conditions, would act with a dignity and decorum worthy of the traditions of the Commonwealth of Massachusetts; but the same wall moved to Chicago took on other attributes suited to the boisterous and ardent temperament of that intensive city; while in California the intoxicating atmosphere and brilliant, exuberant sunshine, kissed to life dormant volatile qualities never suspected in the mouse-like little Puritan of Boston.

The plumbing regulations were equally erratic. Fixture traps that would syphon in Connecticut would act with placid stability in Ohio,

while in the far west they would buck and back-fire when touched with the spur of public discussion.

The technical intricacies of plumbing led the Code Committee to suggest the appointment of a sub-committee on Plumbing; and in response Secretary Hoover invited Dr. Whipple to act as Chairman of such a Committee, and with him seven other gentlemen representing the interests of the sanitary and hydraulic engineer, the master plumber, the journeyman plumber, the research engineer, the manufacturer, etc.

After two years of investigation, conference and research the final report of the Plumbing Committee was submitted and it has been published by the Government Printing Office as a Document of the Department of Commerce. It can be obtained from the Government Printing Office.

To lay a foundation for its work, the Committee asked itself what right has the State to dictate the character of plumbing which a citizen may wish to erect on his own private property?

The answer to this was found in the general police power of the State which empowers it to regulate private activities that may be injurious to the *health, safety,* or *morals* of the community. The Committee did not have far to go to find a monumental precedent for such police authority. While it was evident that the morals of the community were endangered whenever a bill for plumbing invaded the sanctity of the home—the difficulty of securing testimony that would pass the public censor and be confined to the "Rules of Evidence," led the Committee to rear its structure on the firmer foundation of regard for *health and safety.*

It was not so very long ago that the term "*sewer gas*" was used to conceal our ignorance of the character of the air in sewers and drains; and it was thought to be the origin of such minor ills as "Plague, Pestilence and Famine."

In comparatively recent years the chemist and bacteriologist have given us more accurate knowledge. The Committee's view on the Relation of Plumbing to Public Health is expressed clearly in the report in question. (Extracts were read by the writer, from pages 5, 6 and 7 of the report.)

The Committee next applied itself to existing, widely variant plumbing codes (some eighty odd in number) and from them segregated the topics that were more or less uniform and on which all

could agree. It was recognized that the goal of all the codes was health and safety, and that it was only different ideas as to what constituted safety which lead to acrimonious controversies.

A set of basic plumbing principles was then drawn up embracing the fundamentals of safe plumbing without going into detail. (Extracts were read from the report.) The subject was then taken up in detail and the items over which controversial wars have been waged were approached with stern determination to arrive at defensible conclusions. Should the house trap be required? Should all traps be back-vented? Should anti-syphoning or resealing traps be permitted? etc.

It was realized that the differences of opinion existed largely because of lack of accurate knowledge and that experimental investigation was necessary. Through the courtesy of the Bureau of Standards the opportunity was given. The services of an experienced physicist were placed at the disposal of the Committee and facilities were provided for conducting practical experiments.

One hundred and twenty-seven pages of the report are devoted to the report on the Physics of Plumbing, by Dr. R. B. Hunter and L. W. Snyder, of the Bureau of Standards. It contains many new, original and valuable data. (Extracts were read from the report.)

METHOD OF PROCEDURE

Before issuing its final report and during the progress of Dr. Hunter's experiments the Committee prepared a preliminary report, stating its opinions and the conclusions agreed upon at that time. This report was mimeographed in multiple copy and 1000 of them were distributed throughout the country to all those believed to be interested and to be able to criticise it with some knowledge of the subject. Request for criticism and suggestions accompanied the distribution of this preliminary report. About 200 helpful replies were received, both favorable and critical, and were carefully considered and given due weight by the Committee in its final report.

Following a re-study of the subject and at the conclusion of Dr. Hunter's investigation, the Committee draughted and recommended a code for Minimum Requirements for Plumbing in Dwellings and Similar Buildings. (Extracts were read from the report.) The suggested Code comprises 153 sections, covering the essential items necessary to secure safe and efficient plumbing.

In addition to the subjects previously noted, there is a chapter on

the Administration of Plumbing Ordinances; and a Chapter on Standardization of Plumbing Materials. There is also a Chapter of Explanatory Notes giving the reasons why certain conclusions were reached relating to 26 different topics. A number of Appendices are added to the report, including a valuable paper by the late Dr. George C. Whipple on the "Corrosion of metals in plumbing systems" written in terms intelligible to the engineer and layman. There are also eleven tables and 100 cuts and figures.

In conclusion let me say that plumbing, like other activities, is a natural evolution from trade specialization, growing out of the expanding demands of man for greater conveniences of living and luxury in daily life.

Such an activity is necessarily, and should be, in a plastic state adjustable to changing conditions and habits of life. This view was recognized by the Committee and the necessity for periodic revision of the Code to meet such variations and advancing knowledge is recommended as an essential to the permanence of its value.

ADDITIONAL WATER SUPPLY PROJECT FOR EAST BAY MUNICIPAL UTILITY DISTRICT IN CALIFORNIA

By Arthur P. Davis[1]

Oakland and neighboring cities, having a population in 1920 of 334,348, voted last November approval of a bond issue of about $39,000,000 for a new water supply. Construction work is waiting validation of the bonds by court process which will require several months.

This undertaking is a unique one in many ways and it is thought will prove of interest to members of the Association. This District is estimated to grow so that the population will be 501,000 in 1930; 702,000 in 1940; 948,000 in 1950; 1,230,000 in 1960; and 1,540,000 in 1970.

The writer is Chief Engineer and General Manager of this Utility District and George W. Goethals and William Mulholland are consulting engineers.

A report on the water project was made to the Board of Directors of the District on October 1, 1924, from which the main features of the enterprise are excerpted.

INTRODUCTORY STATEMENT

The East Bay Municipal Utility was organized May 22, 1923, and comprises the cities of Oakland, Berkeley, Alameda, Piedmont, Richmond, San Leandro, Albany, Emeryville, and El Cerrito. These cities are all served with water by the system of the East Bay Water Company and the district was formed for the purpose of acquiring this system and for bringing in an additional water supply from a suitable distant source. The district organization is the result of a great many years of agitation, study, and effort to bring to the East Bay Region an adequate water supply. In order to give a clear understanding of the water problem of these cities, it is desirable to consider the history of the present water supply system.

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The Contra Costa Water Company, incorporated August 30, 1906, resulted from the consolidation or purchase of 7 different companies, incorporated at various times from 1865 to 1900. Some of these companies were, in turn, the result of the consolidation of previously existing companies, so that not less than 12 different corporations were represented in the properties of the Contra Costa Water Company. Later this company was consolidated with the Richmond Water Company and the Syndicate Water Company into what was called the Peoples Water Company. The present East Bay Water Company is the result of a reorganization of the Peoples Water Company and the purchase of the Union Water Company. Thus, the present system is the result of the consolidation of many systems, separately planned, and in some cases more or less competitive.

The water supply was originally drawn mainly from wells and a few springs. These were supplemented by the construction in 1874 of Lake Chabot on Lower San Leandro Creek. Since that date this reservoir has been an important water source of the system, but a large portion of the present water supply is still obtained from wells.

That the water situation was considered critical as far back as 1907 is shown by the following quotation from the report of Arthur L. Adams, Engineer for the Contra Costa Water Company: "The present demand for water is in excess of the sources of supply in the event of recurrence of such periods of scanty rainfall as have frequently arisen in the past." Mr. Adams recommended the development of temporary supplies to meet the emergency, which was accomplished by the construction of a number of wells in the Lower San Pablo Valley, but these wells were rapidly depleted, and the larger developments recommended by Mr. Adams were not carried out.

In 1910 the Peoples Water Company announced its intention of meeting the growing needs for water by the installation of meters, and, in a report to the stockholders in 1910, recognized the necessity of an increased supply, but proposed to take advantage of the Calaveras reservoir about to be built by the Spring Valley Water Company, and added the following statement: "Your Directors have reason to believe that the Spring Valley Water Company can furnish any amount that might be required on short notice, and at a fair price. Such action would still further postpone a large capital investment."

In 1918 the water shortage became so serious that irrigation of lawns and gardens was largely prohibited and many of them died. As a result of this shortage, there was constructed on San Pablo Creek a large reservoir with a capacity of 14,000,000,000 gallons and intercepting a drainage area of about 35 square miles. The reservoir capacity is beyond the yield of the basin in ordinary years and is designed to hold the floods of extreme years for use in drier years. It has never been filled since its construction, and will not be until the occurrence of several years of abnormal run-off. The present year is the eighth of a series of years of low run-off

The Water Problem Committee of the Oakland Chamber of Commerce reported, in 1923, in part as follows: "Steps should be taken immediately, to secure at the earliest possible date a much greater supply of water than can be obtained by the fullest development of all local sources of supply, in order that the growth of the community industrially, as well as residentially, be not hampered."

When the spring of 1924 arrived, without the usual winter rainfall, the East Bay Water Company, appreciating that its reservoirs were low and that they could not be replenished for many months, increased its pumping facilities and is now providing pumped water from wells to the extent of about 20 M.G.D., or about two-thirds of the amount being delivered, the balance being drawn mainly from reservoirs on San Pablo and San Leandro Creeks. These reservoirs now contain less than 1,600,000,000 gallons and the present rate of draft will soon empty them.

The heavy draft on the wells, together with the depletion of supply caused by the long dry period, has lowered the water plane in the pumping districts to an alarming extent. In the Alvarado region, from which most of the pumped water comes, careful observations have been taken upon five wells which are typical of the position of the water plane. Prior to 1918, none of these wells had ever shown a stage below sea level. In that year one of them went slightly below, but soon returned above, and all of them remained above sea level until 1920, when four out of the five were drawn below sea level during the dry season to the extent of about 7 feet. The water level in these wells returned to a stage above sea level in the spring of 1921. The same thing occurred in 1922, but in 1923 the water level in four of these wells declined below sea level; the winter of 1924 was so dry that the water level in all of them continued to decline under the gradually increased pumping demand.

The vigorous pumping that this region has received since March, 1924, has caused the water plane steadily to decline until it is 15 to 20 feet below sea level in places. Any increase in the pumping rate, or even its continuance at the present rate, threatens an entrance of salt water into the wells, as they are mostly located in the vicinity of San Francisco Bay.

Although the East Bay Water Company has undertaken the construction on Upper San Leandro Creek of a reservoir having a capacity of about 15,000,000,000 gallons, this reservoir cannot materially assist in relieving the present emergency, as it will require two years to construct the reservoir. The situation, therefore, demands vigorous and prompt action. Although the District may, by good fortune, escape immediate disaster, it is very unwise, and positively dangerous for this community to continue under such precarious conditions regarding its water supply.

This is still further demonstrated by the action of many industries whose managers have investigated the water conditions in the District and have declined to invest. In case of a shortage it is obvious that domestic supply must be given the preference. Many industries have declined to locate in the District for these reasons, and some of the most important in this region have taken the precaution to provide their own water supplies in order to be certain of having sufficient water.

The refinery of the California Hawaii Sugar Company, said to be the largest in the world, undertook to supply its own needs for water by pumping its supply from Carquinez Strait above San Pablo Bay during the season of high water and by hauling it in barges from the Sacramento River during low water. However, the latter supply has failed, as the river water at the head of navigation is too salty for use in the refinery. The situation became so bad in 1920 that the company made a contract with the Marin District at San Rafael, under the terms of which the company built a wharf and long line of cast-iron pipe to bring the water to the wharf, and pay $31,000 per month for the privilege of hauling the water in barges from the wharf.

The Union Oil Company at Oleum obtains a large part of its water supply from Portland and Seattle in the form of ballast, and obtains an additional amount from wells of its own construction. Many other industries provide their own water supply from wells, and are suffering the jeopardy of saline invasion.

The disastrous Berkeley fire of September, 1923, owed its intensity

and persistence in part to the inadequacy of the water distribution system.

Unless remedied, all of these conditions are, of course, not only serious to existing enterprises but disastrous to future growth. The investigations for an additional water supply from a distant source have, therefore, been conducted on the theory that the condition is urgent, that a water supply of acceptable purity and adequate quantity must be brought in with the utmost possible speed and that time is of first importance. It has also been considered desirable to adopt a plan for furnishing an emergency supply of water before the major project can be completed.

MOKELUMNE RIVER PROJECT

Description and present development

The Mokelumne River rises in the Sierra-Nevada Mountains and flows in a nearly westerly direction into the San Joaquin River near Central Landing. The drainage area of the river at Clements, where it emerges from the foothills, is 632 square miles. This river has three principal branches, known as the North Fork, the Middle Fork, and the South Fork. The drainage areas of these tributaries are, respectively, 370 square miles, 75 square miles, and 76 square miles.

The upper part of the basin has a considerable width, but at the junction of the North and South Forks, where the elevation is about 2000 feet, the river is in a narrow canyon with its divides very close to it. Below this point, the drainage basin is very narrow. Hence, the water supply comes from the higher mountains mostly above 2000 feet in elevation. The drainage basin is also practically uninhabited, there being about one inhabitant to the square mile in this portion. There are no good roads, nor prospects of any considerable industrial or other development in this region, and the basin lies largely in the El Dorado and Stanislaus National forests, making ideal sanitary conditions. The water is soft and pure and its general desirability ranks very high. There are no large developments on the Mokelumne River that would interfere with the use of its waters for the East Bay District.

The Pacific Gas and Electric Company has developed a portion of the water supply of the North Fork of the river for power purposes in a plant at Electra, a few miles above Mokelumne Hill. This power system includes 5 small storage reservoirs aggregating about 26,000

acre-feet at Twin Lakes, Upper Blue Lake, Lower Blue Lake, Meadow Lake, and Bear River. Water from these reservoirs is released into the natural stream channels and flows into the headworks of two ditches on the North Fork, one having a capacity of 135 second feet, and the other 75 second feet. These two ditches parallel each other along the northerly side of the river and each has a small forebay reservoir and penstock leading down to the powerhouse on the main river. The head from the higher reservoir is 1466 feet, and that from the lower 1266 feet. The powerhouse has a total generating installation of 20,000 kva., and 30,000 hp. at its water wheels. It will be noted that these diversions of water are returned to the river.

There are two other small ditches diverting waters from tributaries of the North Fork for mining purposes. These small canals are known as the Jackson and Volcano ditches, and have capacities of 20 and 35 second feet respectively. Very little water is now diverted by them.

The Clark ditch diverts a small amount of water from the upper portion of South Fork for mining purposes. This canal has not been in service recently. Further down, the Mokelumne ditch diverts a small quantity of water from the South Fork for Mokelumne Hill and territory beyond, terminating near the Town of Wallace. This ditch seems now also to be abandoned.

A privately owned reservoir site, known as Railroad Flat, has been surveyed and a little construction work done on the foundation of a dam located just below the junction of the Licking Fork with the South Fork about 2 miles north of the Town of Railroad Flat. In connection with this scheme, it has been proposed to build a small reservoir on the Middle Fork about 2 miles northeast of the mouth of Licking Fork to divert the storage of this reservoir, by means of a canal and a short tunnel, into a branch of Licking Fork thence into the reservoir above described. The ultimate feasible capacity of this reservoir, with a dam about 300 feet high, is in the neighborhood of 60,000 acre-feet.

The Mokelumne Project contemplates the construction of a high dam on the Mokelumne River a few miles above Lancha Plana and the conducting of water from this dam across the San Joaquin Valley through the Coast Range into the East Bay District. Two dam sites exist, one just below the mouth of Salt Gulch, and the other about a mile farther down stream, about 4 or 5 miles above the Town of Lancha Plana. By building a dam at either of these points, to a

height exceeding 300 feet, it is possible to divert the surplus water of Mokelumne River over the divide to the northward into Jackson Creek, a tributary of Dry Creek. Below the junction of these two creeks there is a dam site on Dry Creek where there can be constructed a reservoir of very large capacity that would store nearly all of the surplus waters of the Mokelumne River. The reservoir on Dry Creek is called the Dry Creek, or Arroyo Seco, Reservoir. The reservoir on the Mokelumne River is called the Lancha Plana Reservoir.

The elevation of the spillway from Lancha Plana Reservoir into Dry Creek would probably be placed between 550 and 575 feet above sea level. Allowing 50 feet of the upper part of the reservoir for storage purposes, a minimum elevation of 500 to 525 feet above sea level would obtain as against an elevation of 315 feet at the flow line of the San Pablo Reservoir, and of 475 feet at the flow line of the Upper San Leandro Reservoir into which it is proposed to bring the water. It would thus be possible to carry the water to these reservoirs either by gravity alone, or partly by gravity and partly by pumping in accordance with requirements of economy.

The mean annual flow of the Mokelumne River at Lancha Plana Reservoir is about 864,000 acre feet; and the works proposed would permit the complete control of this mean supply by use of Arroyo Seco and Lancha Plana reservoirs. By these means it is possible not only to supply the East Bay District, but to supply water for the irrigation of all of the irrigable lands properly tributary to the Mokelumne River, including all existing rights, riparian or otherwise, below Lancha Plana.

From the Lancha Plana Reservoir to the low country near the East Bay region, it would be necessary to carry the water under pressure in order to lift it to the elevation necessary for storage and use. Whether this elevation be attained by pressure from the reservoir, or by pumping, it will be necessary to have two or more pressure pipes to provide the ultimate capacity of 200 m.g.d. The construction of all but one of these could be deferred for several years, as one large pressure pipe would provide a water supply for the Bay Region for a number of years. Thus the interest on the latter unit would be saved for a term of years, and the initial investment required could be brought within the district's bonding limit.

The most convenient and economical location for the aqueduct would pass between Lodi and Stockton and cross the San Joaquin

River near the railroad crossings of these streams, thence conveniently near Oakley, Antioch, Pittsburgh, Bay Point, Concord, and Walnut Creek into San Pablo Reservoir and Upper San Leandro Reservoir. From Bay Point a branch line could be extended to Martinez, Port Costa, Crockett, Vallona, Oleum, Hercules and Giant.

At the last crossing of the San Joaquin River a pumping plant might be installed to pump water from that level for a temporary supply for the District. By concentrating construction work on this plant and the pipe lines to the westward of it, water could be brought to the East Bay region more quickly than by any other known method.

The waters of the San Joaquin are all appropriated throughout the irrigation season and many storage reservoirs exist for holding the winter and flood waters for summer use, but there is, in all normal years, a large surplus flowing to waste in this stream during the winter, and, while this supply would not be satisfactory as a permanent solution of the water supply problem, draining as it does immense areas of settled and irrigated lands, yet, in the winter when the pollutions are most diluted, it could be used by discharging it into the San Pablo Reservoir and filtering and treating the water drawn from that reservoir through the present filtration plant. For this purpose the San Joaquin River water is much preferable to the Sacramento as there is no pollution in it corresponding to the sewage discharges of the City of Sacramento or the drainage from the rice fields in the Sacramento Valley. All the important cities in the Upper San Joaquin Valley treat their sewage or use it for irrigation, which greatly minimizes these pollutions. The City of Stockton is situated below the point of diversion of the San Joaquin River for the proposed pumped supply. This plan for an emergency supply could be made to fit into the plans for the permanent supply so as to involve very little construction that would need to be discarded when the permanent supply was available.

The Lancha Plana dam, built to a height of 325 feet, is necessary as a diversion to supply water to the great reservoir on Dry Creek which could not otherwise be utilized, as its local drainage is too small for this purpose. The Lancha Plana dam is too expensive to be provided for this purpose by the irrigation interests of Mokelumne Valley, and would be constructed free of cost to that valley by the East Bay District, and serve as a diversion dam to make their irrigation storage on Dry Creek feasible and economical.

The water would be taken from the Lancha Plana reservoir through a tunnel and brought across the San Joaquin Valley by means of pressure pipes to the vicinity of Pittsburgh. There a pumping plant would raise it into a short tunnel through the range which extends from Mt. Diablo to Bay Point, and by means of other pipes and tunnels, the water could be delivered in Claremont reservoir and to the pipes now in use, without filtration or contamination from local supplies. The surplus would be stored in the Upper San Leandro and San Pablo reservoirs to be drawn upon as reserves. It would thus be possible to deliver the water, entirely enclosed in conduits, from the deep reservoir at Lancha Plana through the spigots in the houses of the East Bay District, without any possibility of contamination on the way, and without affording any opportunity for the growth of the organisms which require sunlight. Such a deep, narrow reservoir as that proposed at Lancha Plana is recognized by sanitary engineers as the best possible means of purifying a water supply.

Mr. Freeman's Report contains the following: "Detention of water in a large reservoir, here, as in other reservoirs, is the chief sanitary safeguard relied upon by the health authorities and water works officials of Boston."

Mr. Allen Hazen, one of the leading sanitary engineers of the country, says, in his report: "The storage of water in large reservoirs for considerable periods tends to eliminate, and actually does eliminate, nearly all the effects of pollution upon the water running into the reservoir."

Freeman says of this water: "The quality of water obtainable from the Mokelumne River is good. If taken from a large reservoir, such as proposed for Railroad Flat, and thereafter kept in a closed conduit, it would be safe to use without filtration."

The Lancha Plana Reservoir would be such a reservoir as that mentioned and equally suitable for the purpose.

The water level in Lancha Plana Reservoir would stand above the outlet into San Pabio Reservoir by an amount varying from 260 feet maximum to 125 feet minimum, which would normally be more than 200 feet. It would thus be possible, and entirely feasible, to deliver water into San Pablo Reservoir, or Claremont Reservoir, by gravity, but the computations show that the cost of the aqueduct capacity to deliver this water by gravity would be so great that the interest charge would exceed the cost of delivering the same quantity or water near Pittsburgh and pumping it from that point to an elevation where it would run into San Pablo Reservoir by gravity.

Estimates have been made upon three plans:

a. The delivery of 50 m.g.d. to San Pablo Reservoir by gravity;

b. The delivery of 50 m.g.d. near Pittsburgh and there pumping it 150 feet to flow into the reservoir:

c. Delivering the water by gravity to a lower point near Pittsburgh and pumping it from there to a height of 300 feet, whence it would run into the reservoirs by gravity.

Of these three plans the one involving the pumping lift of 300 feet is the cheapest when the cost of pumping and interest charges are considered. The next cheapest is the 150-foot lift, and it is probable that a lift somewhere between these amounts will be selected as the most feasible. It is, of course, desirable to have the water at this point where it can be delivered to Pittsburgh, Antioch, Bay Point, Martinez, and other points on the waterfront, without pumping, and further studies are required to determine these details.

The feature of this plan which requires the longest time in construction is the Lancha Plana Dam, which can be completed in four or five years after construction begins. The other features requiring long time are the four-mile tunnel leading to San Pablo Reservoir and the long line of steel pipe between Lancha Plana and Pittsburgh. It is believed that either of these features can be completed within three years, and when they are completed, and the Lancha Plana Dam built to a height of 450 feet above sea level, it will be possible to deliver water into the San Pablo and Upper San Leandro reservoirs. It is entirely possible to accomplish this work within four years, but some additional time would be required to entirely finish the Lancha Plana Reservoir to its ultimate height.

There appears to be no reason to doubt that mountain water can be delivered to the district within four years from the time construction begins, provided adequate funds are available.

The possibility of using the Mokelumne River for supplying the City of San Francisco has been investigated several times, and the data made available by these investigations show the existence of thirteen reservoir sites aggregating in capacity 48,301 acre feet, which require dams of various heights up to 110 feet. In addition to these sites, there are two others, one on the north Fork and the other on the South Fork, aggregating a capacity of 151,730 acre feet, and each requiring a dam 325 feet high, the feasibility of which had not been tested. The total capacity of 200,130 is about the same as the capacity of Lancha Plana Reservoir, apparently unknown at that

time, as was, no doubt, the great Arroyo Seco Reservoir with a possible capacity of 1,137,000 acre feet. There are now known to be available for use, instead of fifteen small reservoirs, two large ones with a

TABLE 1

Summary of preliminary estimates of Mokelumne River Project, via Kirker Creek

ITEM	LENGTH	FIRST UNIT	SECOND UNIT	THIRD UNIT	TOTALS
		Construction periods			
		Three unit development			
	Miles	1924–28 50 m.g.d.	1942–44 75 m.g.d.	1964–66 75 m.g.d.	200 m.g.d.
1. Gravity line........	86.1				
Estimated cost....		$39,372,000	$28,101,000	$28,101,000	$95,574,000
Interest during construction.....		3,937,000	1,405,000	1,405,000	6,747,000
Capitalized pumping charges.....		0	0	0	0
Total.............		43,309,000	29,506,000	29,506,000	102,321,000
Present worth.......		43,309,000	12,863,000	4,406,000	60,578,000
2. 150-foot pump lift...	87.01				
Estimated cost....		34,541,000	20,320,000	20,063,000	74,924,000
Interest during construction....		3,454,000	1,016,000	1,003,000	5,473,000
Capitalized pumping charges.....		2,520,000	2,600,000	4,580,000	9,700,000
Total..............		40,515,000	23,936,000	25,646,000	90,097,000
Present worth.......		40,515,000	10,435,000	3,830,000	54,780,000
3. 300-foot pump lift...	89.31				
Estimated cost....		32,167,000	13,663,000	13,173,000	59,003,000
Interest during construction....		3,217,000	683,000	659,000	4,559,000
Capitalized pumping charges.....		4,240,000	4,680,000	7,880,000	16,800,000
Total..............		39,624,000	19,026,000	21,712,000	80,362,000
Present worth.......		39,624,000	8,295,000	3,242,000	51,161,000

combined capacity seven times as great as the fifteen, intercepting more than double the drainage area, and so situated that the mean run-off of this total area can be entirely conserved. This gives a

radical difference in conditions from those known at the time of the earlier investigations.

Estimates of cost of Mokelumne River project

The estimates of cost of the Mokelumne River Project are based on the building of the Lancha Plana Reservoir and the bringing of 200 m.g.d. of water in an aqueduct from this reservoir across the San Joaquin Valley and over and through the Coast Range into San Pablo and Upper San Leandro Reservoirs. In order to do this it is necessary to provide for the prior water rights on the Mokelumne River by a contractual contribution towards the construction of Dry Creek Reservoir from which irrigable lands are to be served.

A summary (table 1) follows of the preliminary estimated costs of the various units just described and their present worths brought down to the mid-construction periods of the first units, the investment in each unit being assumed to have been made at its mid-construction period. Of the various schemes considered it will be noted that the cheapest is the combination gravity and pumping scheme involving a 300-foot lift and developments of 50, 75 and 75 m.g.d. as the estimated needs demand.

MANGANESE IN LAUNDRY AND PIPE LINES

By H. C. Kneeland[1]

A plant of about 3 million gallons daily output, serving a western Pennsylvania community and taking its supply from about 40 feet of glacial valley train of Wisconsin age in the Ohio River valley, has for the past three years experienced troubles with pipe line deposits and yellow laundry stains entirely similar to those described for Baltimore (Journal, October, 1924, page 211).

This water supply, which is classed as a ground water, has contained manganese for less than five years, the exact date and possible source not yet having been determined, and has caused laundry troubles since the early part of 1921.

For the past three years the manganese content has not varied beyond the limits of 1.5 and 2 parts per million in a water containing only a trace of iron, an average total hardness of 190 and a very low dissolved oxygen. Crenothrix is also present.

In water freshly taken from the wells the manganese is undoubtedly in solution in a very clear water but oxidizes in the pipe lines to form small black particles of manganese dioxide which are carried along in the rapid flow in the larger mains to lodge in small pipes and service lines especially in high points of the territory. Many services have been so reduced in size of opening as to result in lack of pressure and volume and a few have been completely closed.

When badly clogged service lines first began to give trouble in the spring of 1924, an attempt was made to open them with a stiff wire, which was never very successful, and most of them were taken up and relaid. Later it was found that a judicious use of hydrochloric acid was very successful in dissolving out the deposits.

Most of the houses, especially those in the higher parts of the territory, stand upon high terraces and accordingly have the water meter at an elevation of from 10 to 30 feet higher than the water main in the street. To clean a service in such a location, both ends of the service were disconnected by digging down to expose the

[1] Chemist, Ohio Valley Water Company, McKees Rocks, Pa.

ferrule and by removing the meter connections. To the house end of the service line there was then connected a short length of lead pipe having at one end a threaded iron pipe nipple and the other end enlarged to receive the stem of a glass funnel. About half a gallon of commercial muriatic acid was slowly poured into the funnel and allowed to seep through the service and discharge into a bottle or run away in the ditch. It usually required from five to ten minutes for the acid to make its appearance as a dirty froth followed by a thick muggy liquid with chunks of black oxide suspended in it. When practically all of the acid has come through, the ferrule was again connected to the main and the house end of the pipe led to the cellar drain. The ferrule was then opened and the line flushed until clean, which required about twenty minutes.

During the flushing process it was discovered that the removal of sediment was hastened by suddenly opening and closing the ferrule in such a way that the surges of water in the line produced a sort of ram which jarred loose any clumps of material attached to the sides of the pipe. Later it was found possible to clean some services by means of this water ram alone without using the acid treatment. This, however, requires skill acquired in practice and sometimes, if too much water be sent through, results in complete choking of the line by the disturbed sediment.

LAUNDRY TROUBLES

At Baltimore, with only 0.1 to 0.2 p.p.m. of manganese, trouble was reported only from public laundries using bleach etc., but in the case here considered, with about 60 per cent of the original 2 p.p.m. of manganese oxidizing and precipitating in the mains, the water in the territory contains from 0.6 to 0.8 p.p.m. which is quite sufficient to make trouble in home laundries.

Manganese arrives in the wash tub in soluble condition, possibly as the sulphate or supported by some weak organic acid, but is promptly converted to the hydrate by reaction with the strongly alkaline softening powders invariably used with this water, which constantly has a hardness of about 200 p.p.m., and in this hydrate form clings to the fiber of the cloth or to the dead soap which remains in the fabric after rinsing. Usually when clothes are dried rapidly in bright sunshine and fresh air, no trouble ensues, but if the drying be delayed as upon a damp day or, if clothes be dampened and left rolled up for an hour or so, the manganese undergoes a change to a

brown hydrate or one of the colored oxides of manganese and staining of clothes results. Table linens with greasy places, the middle of pillow cases where hair has touched and collar bands of shirts are the first and worst places stained.

Oxalic and tartaric acids and all the agents usually mentioned in articles about manganese troubles were tried with more or less success, but, in this case, the writer took advantage of the apparently little appreciated fact that manganese hydroxide is soluble in solutions of most of the ammonium salts and used ammonium chloride (sal ammoniac) to remove all of the discoloration from badly stained linens. At his suggestion, the water company bought several barrels of a commercial grade of ammonium chloride (10 cents per pound) for distribution, in two pound lots, to consumers who made complaint to the office.

About a pound of ammonium chloride in sufficient boiling water to half fill a common wash boiler will remove the spots from any ordinary batch of washing if clothes be boiled in it for about ten minutes. Half a pound dissolved in the first (hot) rinse water keeps the manganese hydrate in solution and allows it to be removed by rinsing and thus prevents stains from forming later. Clothes treated in this way can be dampened and rolled without injury. In addition to its low price and efficincy for the purpose, ammonium chloride has the additional advantage of being totally harmless to clothes, skin and the copper wash boilers or washing machines in which it is used.

OPERATION RESULTS AT THE WATER PURIFICATION PLANT AT TOPEKA, KANSAS[1]

By N. T. Veatch, Jr.[2]

The water purification plant at Topeka, Kansas, has now been in operation for approximately two years and an article descriptive of the results obtained from the treatment of the hard, muddy and polluted Kansas River water may be of interest at this time.

A very complete description of this plant is given in the Engineering-News of July 27, 1922, to which article the reader is referred for details of construction.

The plant consists of aerators, grit chambers, mixing chamber, settling basins, pre-filters, coagulating basin, final filters and sterilizing apparatus.

Equipment is provided for feeding alum, lime, soda ash and chlorine, so that the plant can be operated either for the clarification of the turbid river water alone or for clarification combined with softening.

The nominal capacity of the plant as regards preliminary treatment i.e., aeration, settling, mixing, and coagulation is eight million gallons per day, and filter equipment is provided for a normal rate of six million gallons per day.

Raw water. The character of the water of the Kansas River is extremely variable and this stream as regards water supply may be classed as hard, turbid and polluted. In table 1 the average monthly turbidities, alkalinity, total hardness, bacterial count and B. coli index are shown and these figures represent conditions familiar to most of the purification plant operators of the Middle West.

Day to day and even hour to hour variations in turbidity and other characteristics are frequent and often wide, and constant vigilance in adjusting chemical feeds to existing conditions is a prime requisite for successful operation.

Water consumption. During 1923 a total of 1,475,250,000 gallons

[1] Presented before the Iowa Section meeting, November 7, 1924.

[2] Consulting Engineer, Kansas City, Mo.

TABLE 1

MONTH	AVERAGE TURBIDITY	AVERAGE ALKALINITY	AVERAGE TOTAL HARDNESS	BACTERIAL COUNT	B. COLI INDEX
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
January	218	258	250	2.815	15.85
February	119	264	295	2.106	2.33
March	369	228	261	3.957	12.25
April	1,411	208	242	5.242	27.10
May	3,445	153	202	18.420	37.70
June	3,940	125	139	15.760	152.50
July	3,290	128	134	16.500	*
August	1,358	158	174	11.960	50.00
September	1,195	195	237	1.900	203.00
October	1,579	165	192	9.000	85.00
November	199	236	270	5.120	2.70
December	154	254	298	1.910	3.80

* B. coli tests not made this month.

TABLE 2

Amount of water treated at Topeka plant during 1923

	TOTAL FILTERED	WASH WATER	WASH WATER	AVERAGE DAY	MAXIMUM DAY
	million gallons	*million gallons*	*per cent*	*million gallons*	*million gallons*
January	122.38	2.110	1.73	3.98	5.63
February	111.56	1.91	1.72	3.99	4.74
March	118.43	2.05	1.73	3.83	4.53
April	111.12	1.93	1.73	3.71	4.45
May	117.80	1.60	1.36	3.78	4.98
June	123.12	2.34	1.90	4.10	5.50
July	131.01	2.27	1.73	4.22	6.05
August	135.67	4.49	3.65	4.37	5.35
September	126.62	2.98	2.35	4.21	5.13
October	127.69	3.61	2.83	4.13	5.52
November	129.55	3.75	2.90	4.30	5.55
December	120.30	3.03	2.51	3.87	4.55
Total	1,475.25	32.52			
Average			2.20	4.40	

of water or an average of approximately 4,040,000 gallons per day were treated, at this plant, of which approximately 97.9 per cent or 3,951,000 gallons were pumped to the City.

Table 2 shows the monthly average rates together with the maximum each month.

In 1920 the City of Topeka used an average of 3,600,000 gallons per day with a maximum of 4,700,000 gallons and the increased present consumption, approximately 12 per cent, represents in part the normal growth of the City, but is also due to the fact that the present water supply is entirely adequate and more popular than the old ground water supply which contained considerable iron and was quite hard.

Low service pumpage operation. Water is pumped from the river or from the old system of wells, if desired, into the aerator by means of motor driven centrifugal pumps, through a discharge line which is fitted with a float controlled valve for the purpose of maintaining the water level in the basins at the proper elevation.

Aerator. The aerator is of the multiple pan type with a total weir length of 900 feet and a drop of 15 inches. With river water the principle service of the aerator is the elimination of odors from decayed organic matter which are at times quite evident in the raw water and the aerator is also of service in removal of carbon dioxide from the raw water preparatory to softening, but due to the usual high turbidity of the water and the resulting difficulty in making dissolved oxygen or carbon dioxide tests no attempt has been made to determine its actual efficiency.

Grit chamber. The grit chamber which was designed for a detention period of one hour (at an 8 million gallon rate) has during 1923 actually had an average period of from 111 to 126 minutes and as a result more sedimentation has taken place here than was intended. A large amount of relatively large sized grit and sand is pumped up with the raw water and this makes the sediment from this basin hard to handle.

The floor of this basin is filled with underdrains which terminate in 1¼-inch openings in the floor spaced 5 feet, on centers, both ways, and which lead to headed pipes fitted with quick opening valves.

The system has not proven an unqualified success, due to the relatively large amount of grit and it has been found necessary to empty this basin several times and flush out the heavy sediment with fire streams, but it has saved a considerable amount of time and

water, since, with this system, the period between flushings is materially longer than would be the case if flushing alone were relied upon.

Mixing chamber. The mixing chamber has a capacity of approximately 180,000 gallons and is intended to provide a period of 30 minutes at the nominal rate of 8 million gallons per day, but, under actual conditions during the past year, this period has been from 60 to 71 minutes.

Thorough mixing is obtained by the operation of motor driven agitators or paddles and by the flow of the water itself through the baffled basin.

This system of mixing, while entirely adequate, has two defects. First, the normal wear and tear on gears, bearings and other mechanical parts, and second, the tendency of dissolved lime to accumulate in the corners formed where the baffles join the walls of the basins, which accumulation tends to clog the underdrains.

Care and attention are required for the mechanical parts and the second defect has been overcome by placing water jets in the corners where the accumulation occurs to keep the sediment in motion.

Chemical feeding equipment. Alum is fed in the form of solution through orifice boxes so located that it may be applied at the entrance of the mixing chamber, the entrance to the settling basins and the entrance to the coagulating basin. Lump alum is used and the solutions are made up in two wood stave solution tanks located on the second floor of the plant.

Hydrated lime is fed through two dry feed machines fitted with steel hoppers which permit of feeding this dusty chemical from a separate room on the second floor. The application of lime is made at the entrance to the mixing basin only.

Soda ash when used is fed through dry feed machine direct into the mixing basin.

Motor driven agitators are provided in the hoppers of the lime and soda ash machines to prevent "caking" of the chemical.

Settling basins. From the mixing chamber the water flows by gravity into the settling basins, two in number with a combined capacity of 1,950,000 gallons or 6 hours flow for the nominal capacity of 8 millions and from 10.6 to 12.5 hours flow for the draft during 1923.

The basins are operated in parallel and are filled with skimming weirs at each end and "A" frame baffles in the center.

The water depth is 16 feet and the average velocity in the basins was during 1923 from 0.15 to 0.18 foot per minute.

The settling basins are filled with underdrains similar to those in the grit basin and due to the more finely divided condition of the sediment their operation is much better. There is a tendency for them to clog however at the inlet end of the basin and at the extreme ends of the laterals, and it has been necessary to flush the basins out with fire streams at intervals of approximately six months.

Roughing filters. The roughing filters are three in number and are similar in construction to the final filters with the exception that the filtering material is an 18-inch layer of $\frac{1}{4}$-inch screened Joplin chats, laid on a graded ground bed.

These filters are operated at a rate of 4 gallons per minute per acre or approximately double the rate of the final filters and while little or no clarification of the water is effected, the real purpose of the filters, i.e. the removal of excess carbonate hardness, is fulfilled as shown by the fact that during 1923, the carbonate alkalinity of the water applied to the filters as shown by the monthly average results did not exceed 13 parts per million.

Coagulating basin. The coagulating basin, which receives the water from the roughing filters and delivers it to the final basin is similar in construction and size to the grit basin except that it is baffled.

The time of coagulation is from 110 to 130 minutes under present conditions, which time will be reduced to 60 minutes when the capacity of the plant is reached. The present velocity within the basin is approximately 3.3 feet per minute.

Final filters. The final filters are six in number, each with a nominal capacity of one million gallons per day. They are hydraulically operated throughout and of standard construction, except for the underdrains in which perforated pipes have been substituted for the standard strainer system.

Excellent results have been obtained with these filters since they were put into operation and in 1923 the wash water used amounted to 2.2 per cent of the total. The average turbidity of the settled water for the same period was 73 parts per million.

Sterilizing equipment. The original sterilizing equipment consists of a duplicate installation of Wallace and Tiernan manometer type liquid chlorine machines, but in the fall of 1923 the city installed two electrolytic cells of the Williams type and these were

See p 207

FIG. 1

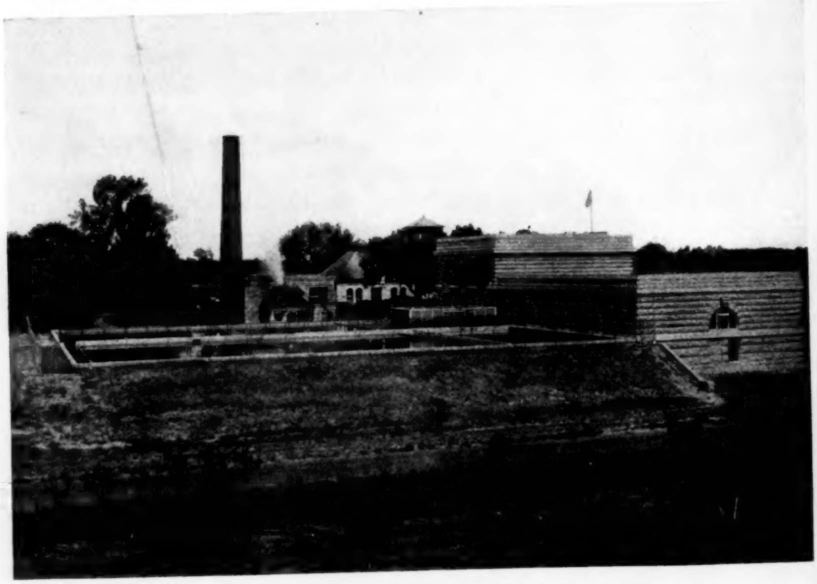


FIG. 2

operated during November and December and, intermittently, since that time.

Sufficient data are not at hand to determine the actual cost of sterilizing with the electrolytic cells, since they have not yet been used long enough for a thorough trial and since the cost of the electric current which is produced at the pumping plant has not been determined accurately.

There seems to be no difference in the results from the two systems, however, so far as sterilization of the water is concerned, which would be expected, since a pound of chlorine gas will naturally do the same work regardless of its origin.

Operation. The water purification plant is under the supervision of a chemist, and the operating force consists of three operators, each of whom has an eight hour shift. Extra help for maintaining the grounds, buildings and equipment, cleaning basins or other work not connected directly with the operation of the plant is furnished as needed by the water department.

Plant control. The laboratory tests for the control of the plant are as follows:

1. Turbidity: Run on raw and settled water daily or oftener if the condition of the water seems to be changing.
2. Alkalinity: Run on raw, settled and filtered water daily.
3. Carbonate alkalinity: Run daily, or oftener on settled and filtered water.
4. Total hardness: Run daily on raw water and filtered water, by soda reagent method.
5. Free chlorine: Run on sterilized water daily or oftener. (Ortho-tolidin method.)
6. Bacterial counts: Run daily on raw, settled, filtered and sterilized water. (Nutrient agar plates incubated 24 hours at 37° C.)
7. B. coli: Run daily on raw, settled, filtered and sterilized water. (Presumptive tests in lactose broth read at 24 and 48 hours incubation at 37°C.)
8. Mineral analysis: Run on raw and filtered water each month on a composite sample made up of portions of each days run.

The proper amount of the various chemicals to be fed is determined each day by the chemist and his instructions are placed on a black board in the operating room.

Daily records are kept on the operation of the filters, the chemical feeding rates and analytical results, and the quantity of water treated

and these records are summarized each month for the permanent plant record.

Results. When the plant was put into operation it was decided to produce a treated water with not more than 135 parts per million

TABLE 3

Hardness of raw and treated water

	TOTAL HARDNESS OF RAW WATER	TOTAL HARDNESS OF TREATED WATER	REDUCTION
	p.p.m.	*p.p.m.*	*p.p.m.*
January	250	167	83
February	295	166	129
March	261	153	108
April	242	137	105
May	202	138	64
June	139	111	28
July	134	107	27
August	174	135	39
September	237	131	106
October	192	133	59
November	270	139	131
December	298	127	171

TABLE 4

	TURBIDITY		BACTERIA PER CUBIC CENTIMETER		B. COLI INDEX	
	Settled water	Filtered water	Filtered water	Sterilized water	Filtered water	Sterilized water
	p.p.m.					
January	72	None	86	71	1.485	0.0000
February	18	None	37	18	0.04	0.0020
March	36	None	35	24	0.362	0.0000
April	50	None	71	41	0.45	0.0192
May	140	None	84	47	2.80	0.0000
June	145	None	89	44	1.53	0.0033
July	58	None	74	46		
August	67	None	108	44	1.36	0.0000
September	112	None	126	85	0.48	0.0000
October	69	None	101	47	0.87	0.0064
November	59	None	78	28	0.07	0.0000
December	52	None	37	17	0.09	0.0000

of hardness, but on trial it was found that the sudden change from the hard well water was not popular and resulted in so many pro-

TABLE 5

	ALUM USED DURING MONTH	GRAINS PER GALLON	LIME USED DURING MONTH	GRAINS PER GALLON	SODA ASH USED DURING MONTH	GRAINS PER GALLON	CHLORINE USED DURING MONTH	POUNDS PER MILLION GALLONS
	pounds		*pounds*		*pounds*		*pounds*	
January	13,540	0.77	105,750	6.04			368.7	3.05
February	14,000	0.88	114,900	7.22			350.0	3.06
March	22,050	1.30	91,450	5.40	13,400	0.94	348.5	2.94
April	39,550	2.45	80,150	5.05	14,300	0.92	373.0	3.36
May	75,500	4.52	76,900	4.57	17,800	1.07	475.5	4.42
June	100,100	5.70	78,550	4.46	10,500	0.61	491.2	3.98
July	68,800	3.68	57,650	3.06	9,800	0.53	547.2	4.38
August	28,550	1.50	63,850	3.36	8,100	0.43	568.5	4.27
September	22,600	1.25	85,600	4.72	13,700	0.78	443.5	3.52
October	41,500	2.27	65,350	3.58	4,650	0.56	535.5	4.21
November	11,700	0.63	102,950	5.57	11,890	0.65*	276.0	3.41
December	11,700	0.68	136,850	7.80	18,250	1.09		
Total	449,590		1,059,950		122,390		4,804.6	
Average		2.14		5.13		0.75		

* Nineteen days only.

TABLE 6

MONTH	COST OF LIME	COST OF SODA ASH	COST OF ALUM	LABOR AND SUPERVISION	CHLORINE COST	TREATMENT COST	MILLION GALLONS TREATED	COST PER MILLION GALLONS
January	560.47		234.24	600.00	47.93	1,442.64	122.4	11.78
February	607.87		242.20	600.00	45.50	1,496.57	111.6	13.46
March	484.68	234.50	381.46	600.00	45.40	1,746.04	118.4	14.74
April	424.80	250.25	684.22	600.00	48.50	2,007.77	111.1	18.06
May	407.52	311.50	1,301.15	600.00	62.00	2,682.17	117.8	22.76
June	416.32	183.75	1,731.73	600.00	63.80	2,995.60	123.1	24.33
July	305.54	171.50	1,190.24	600.00	74.60	2,341.88	131.0	17.87
August	338.40	141.75	483.91	600.00	73.90	1,637.96	133.7	12.25
September	453.68	239.75	390.98	600.00	57.60	1,742.01	126.6	13.75
October	346.36	81.38	717.95	600.00	69.70	1,815.39	127.7	14.21
November	545.64	208.08	204.75	600.00		1,558.47	129.5	12.03
December	725.30	319.37	204.75	600.00		1.849.42	1,120.3	15.37
Average								15.82
Total	5,618.00	2,147.00	7,780.00	1,800.00		23,315.92	1,473.20	

tests from the water users that the softening was partially eliminated with the intention of increasing it gradually so that the effect would not be so noticeable.

The old supply, as is usual with hard iron waters, had a noticeable taste and the change from this to softened water with little or no taste, caused many complaints of "flat taste," "druggy taste," etc. During 1923, however, the total hardness of the treated water was gradually reduced from 167 to 127 parts per million and no complaints have been made.

Table 3 gives the hardness of the raw and treated water by months during 1923

The records of turbidity and of bacterial tests are given here in table 4 and show that the treated water has been clear, and that the limit of bacterial contamination established by the United States Public Health Service has not been exceeded.

Chemical treatment. The amount of the various chemicals used during 1923 is given in table 5.

Cost of treatment. The cost of treatment, in dollars, exclusive of overhead charges, maintenance and power, are given in table 6 by months for the year 1923.

AERATION OF WATER AT FORT WORTH, TEXAS

By W. S. Mahlie[1]

Fort Worth derives its municipal water supply from Lake Worth. This lake was formed by building a dam on the West Fork of the Trinity River, about 6 miles west of the city The lake is about 14 miles long and has a very irregular shore line It covers about 5430 acres, and has a drainage area of about 1865 square miles. The capacity of this impounded lake to spillway level is about 15,000,000,000 gallons. The dam is about 3200 feet long, of which 700 feet is concrete spillway. The earthen portion of the dam is built of clay and sandy loam laid up in one foot horizontal layers, well wetted and rolled. The concrete spillway is designed to carry ten feet of overflow. The dam is 59 feet high and 85 feet thick at the bottom, resting on solid rock.

Water is taken from the lake through a concrete tower with screens at about 12 feet below spillway level. A 48-inch line of reinforced concrete pipe extends for 13,600 feet toward the filter plant. At this point the line is reduced to 36-inch and has a valve placed in it. The remaining 18,800 feet of this line continuing to the filter plant is in rather bad condition from leaks and for this reason the valve is throttled, and the entire available static head from the lake to the filter plant is never developed.

At the filter plant the water first passes a valve then through a 30- by 13-inch Venturi meter, to the aeration basin, the dosing channel mixing basin, coagulation basins, rapid sand filters and finally storage reservoirs.

The lake was finished in 1914. The supply line to the filter plant was not placed in service until 1916, as it was not completed until then. In 1913 a 5 million gallon rapid sand filter plant was completed, but had to use water from the Clear Fork of the Trinity River mixed with water from artesian wells until water was available from Lake Worth. There was considerable complaint from taste and odor, and when it became necessary in 1918 to enlarge

[1] Chemist in charge, Filtration Plant, Fort Worth, Texas.

the plant, provision was made for aeration. At this time an aeration basin, two coagulation basins of one and a quarter million gallons each, and four $1\frac{1}{4}$ million gallon rapid sand filters were added. At the present time work is being completed on more mixing basin, two million gallon coagulation basin, eight $1\frac{1}{4}$ million gallon rapid sand filters, a two million gallon clear well and other details.

One of the distinctive features of the present plant is the aeration basin, shown in figure 1. It is built of reinforced concrete superimposed over the first settling or coagulation basin, supported by the necessary concrete columns. This basin is 85 feet wide, 111 feet long, and $3\frac{1}{2}$ feet deep. At the north end of the basin, (that end

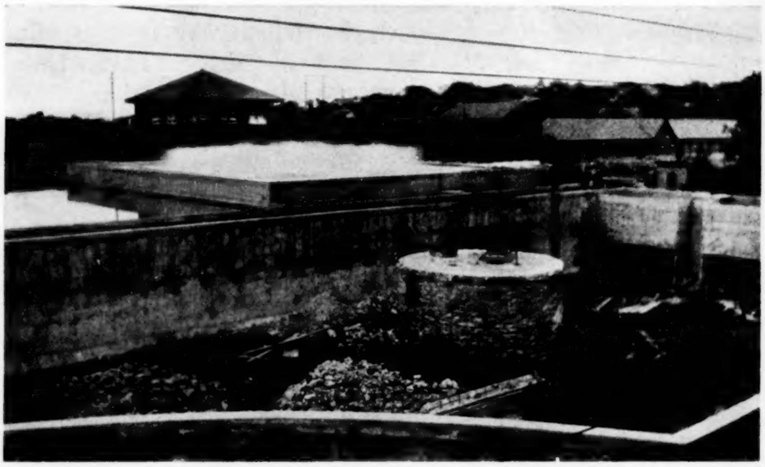


Fig. 1

nearest the chemical house) a weir is built 5 feet from the end wall. This weir is $2\frac{1}{2}$ feet high, and forms a channel through which the aerated water must flow to the east end. The aerated water is collected in a cast iron pipe placed flush in the bottom at this point. Water is discharged from 64 nozzles arranged on five independent pipe lines branching off from the main line entering the plant just after passing the Venturi meter. A valve is so placed that these lines can be cut off by the smaller valves, and the water can be admitted directly to the dosing channel, permitting the aeration basin to be by-passed for cleaning. The arrangement of these five pipe lines is shown in figures 2 and 3. The two outer lines are 14

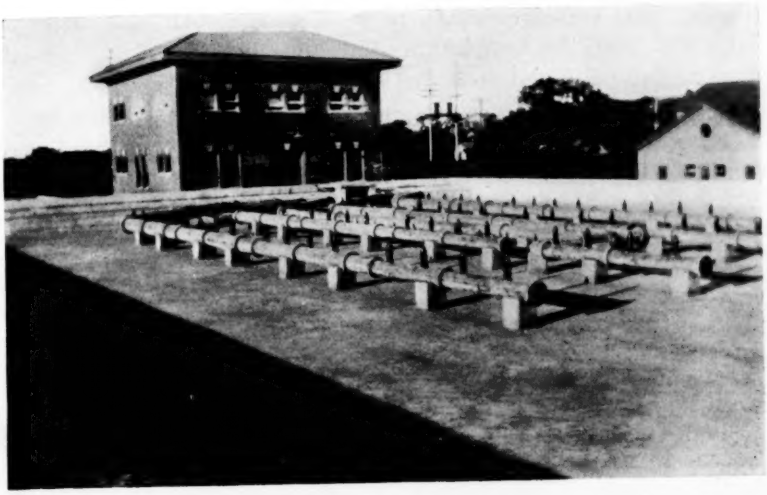


Fig. 2

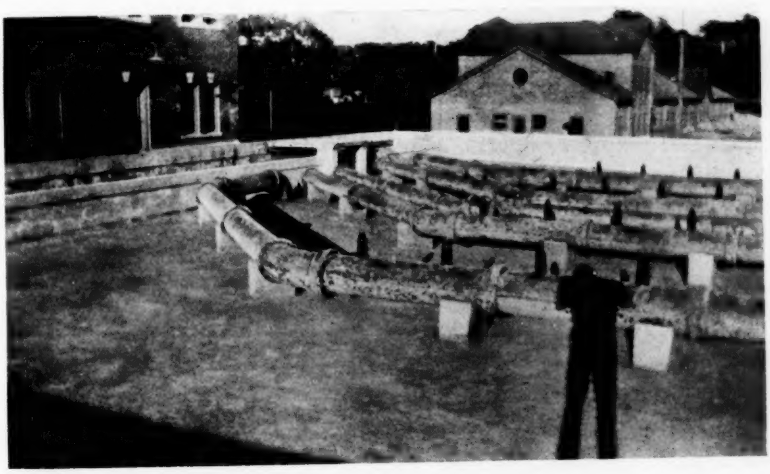


Fig. 3

inches in diameter, and the three inner lines are 12 inches in diameter. These lines are further reduced to 12-, 10-, and 8-inch at the proper places. The two outer lines carry 16 nozzles each, the center line carries 8, and the two intermediate lines carry 12 nozzles each. This permits different combinations so that the rate of flow can be varied without unnecessary manipulation of valves by throttling.

The nozzles are of the "Spraco" type made of bronze. Each nozzle is capable of discharging 150 gallons of water per minute with 10 pounds available pressure at the base of the nozzle. The nozzles are threaded for 3-inch standard pipe at the base.

Figures 4 and 5 show the nozzles in service. At this time the gage pressure at the base of the nozzle was $7\frac{1}{2}$ pounds. The photographs were taken while the basin was empty, just after cleaning. Under ordinary operating conditions the water level in the basin is about 2 inches below the tip of the nozzles.

Requests have reached us a number of times asking for information as to what results we obtain by aeration. Giving expression to these results is somewhat of a difficult matter. It is true that certain portions can be expressed by figures, but when it comes to taste and odors it is extremely difficult to apply figures.

Quite a large amount of material has been written on the subject of aeration, but most of it has been on the removal of iron and manganese.

In general, aeration devices appear to have been developed along two lines mainly:

1. For the removal of dissolved gases and subsequent precipitation of materials held in solution by these gases, such as iron and manganese.

2. For the oxidation of offensive organic matter held in solution.

In the removal of gases, carbon dioxide is usually the predominating one. In some cases, however, hydrogen sulphide is removed. From a standpoint of gas removal aeration is generally considered very successful. However, from the standpoint of oxidation of organic matter, some difference of opinion is found to exist. Mason in his "Water Supply" mentions aeration a number of times. On page 208 he says, "aeration tends to prevent the abundant growth of algae"—while on page 223, mention is made that Professor Leeds' experiments conclude that direct oxidation does not take place. Frankland points out that, "to think to get rid of organic matter by exposure to air for a short time is absurd."

Fig. 4

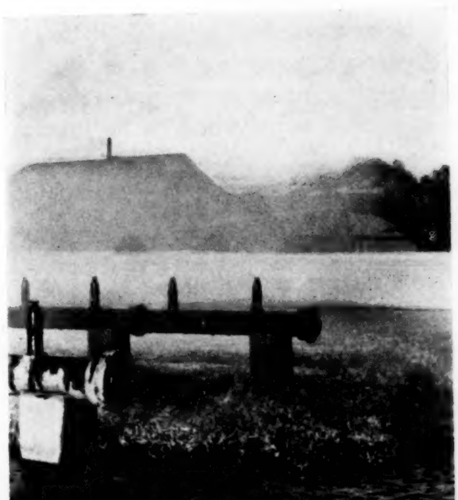


Fig. 5

Ellms in "Water Purification," page 346, says "aeration of water to remove obnoxious gases or volatile matter producing offensive odors is frequently required in water purification."

Whipple speaks of anaerobic respiration and makes mention of Hazen and Allens' report on the Ashokan and Kensico projects that "aeration and filtration will give a uniform water, and that there would be no appreciable differences whether the reservoir site is stripped or not as long as aeration and filtration are resorted to."

Hazen and Allen strike a keynote when they make a distinction in the method of aeration by spraying and that of aeration by exposure in a conduit.

Turneaure and Russel, page 163, state "that aeration failed to show any material effect," and give the results of experiments by Leeds on water above and below Niagara Falls.

These few instances will show that there is some diversity of opinion in regard to aeration.

In the days before Fort Worth had a filter plant the main source of supply was a large number of artesian wells from 300 to 1200 feet deep. At first these were free flowing, but in time the flow diminished and it became necessary to pump them by various means and eventually a surface supply had to be procured. The water from wells of this character is rather high in sodium bicarbonate and has the characteristic slippery sweet taste, peculiar to those waters.

When the city changed from this well water to surface water considerable dissatisfaction was expressed, even going so far as being the basis of a number of political campaigns. These complaints were all on account of taste. The public had become accustomed to this artesian water taste, and naturally a surface water had a different taste.

At the present time for ten months in the year there is no noticeable taste or odor other than that characteristic of a surface water of medium hardness of about 100 to 125 parts per million calcium carbonate. During the other two months, extending from the middle of August to the middle of October, a characteristic taste and odor are present. This is not so obnoxious that the water cannot be used, but, to those accustomed to the artesian water taste, the contrast is very marked. This is further accentuated by the temperature of the water. In water that has been iced (and in

this season of the year practically all water for drinking is iced) the taste is decidedly less than in the water drawn direct from the tap without cooling.

Table 1 shows the results of some tests made on the water before and after aeration.

.It will be noticed that these tests were made at three different seasons in the year. The first series was made when the water had a decided taste. The second series when the taste and odor were absent, and the third series when the water was passing from a "tasty" to a "non-tasty" state.

These samples were all taken immediately after aeration and analyzed without any delay of time.

It will be apparent that any beneficial results in the removal of taste and odor depend upon a mechanical exchange of dissolved gases, when considered without the time factor, and throughout all this discussion it should be kept in mind that this test refers only to the *immediate results* of aeration, without consideration of time factors, and it does not in any way take in consideration the various steps subsequent to this aeration.

When time is allowed for the dissolved oxygen to act biologically, then it is evident that there will be some oxidation of the dissolved organic matter.

A study of the figures in table 1 will show the following:

Temperature. There are slight changes in temperature due to aeration, depending upon the relative temperatures of the air and the water. If the water and air are nearly the same temperature the changes are slight. If there is a very appreciable difference between them, then the changes are greater.

Turbidity. There is no measurable difference in the turbidity before and after aeration, although there is some slight reduction due to the retention of the basin. We always find some mud has settled out in the basin when we clean it.

Color. No changes are detected.

Odor and taste. These are considered collectively. The taste is usually more noticeable than the odor, and the test is, strictly speaking, on the taste. This is probably the most important and yet the most difficult of expression. We have at different times, submitted samples of the water before and after aeration to disinterested persons without informing them which was aerated and which was not. The results are not dependable and in most cases

TABLE 1

SAMPLE NUMBER	DATE	TIME	TEMPERATURE			TURBIDITY		COLOR		ODOR		DISSOLVED OXYGEN		PER CENT SATURATED		FREE AMMONIA		ALBUMINOID AMMONIA		NITRITES		NITRATES		OXYGEN CONSUMED		REMARKS
			Air	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	Raw	Aerated	
	1922																									
1	September 11	2:10 p.m.	77	78	76	52	50	5	5	3E	3E	3.9	7.7	47	91							0.15	0.15	4.3	3.9	Water has taste
2	September 12	1:00 p.m.	78	76	76	40	40	5	5	3E	3E	4.5	7.8	53	93	0.012	0.012	0.144	0.144	0.010	0.010	0.10	0.09	3.4	3.4	
3	September 13		81	76	76	30	30	5	5	3E	3E	4.7	8.0	56	94	0.016	0.016	0.128	0.128	0.007	0.007	0.08	0.11	3.8	3.7	
4	September 14		90	77	78	25	25	5	5	3E	2E	5.0	7.8	60	94	0.014	0.014	0.122	0.120	0	0	0.10	0.09	3.9	3.3	
5	September 15		85	77	77	26	25	5	5	3E	2E	4.8	7.8	57	94	0.012	0.014	0.144	0.136	0.001	0.001	0.12	0.12	3.5	3.4	
	1923																									
6	January 3	1:30 p.m.	61	51	51	20	20	3	3	1E	1E	10.7	11.2	96	100	0.004	0.006	0.128	0.128	T	T	0.12	0.12	3.9	3.9	Water has no taste
7	January 4	1:00 p.m.	63	51	51	20	20	5	5	1E	1E	10.6	11.1	95	100	0.002	0.002	0.118	0.116	0.002	0.002	0.12	0.12	3.5	3.4	
8	January 5	1:30 p.m.	62	51	51	20	20	5	5	1E	1E	10.6	11.2	95	100	0.002	0.002	0.104	0.106	0.002	0.002	0.10	0.10	3.8	3.6	
9	January 6	10:00 a.m.	52	50	50	20	20	5	5	1E	1E	10.6	11.2	94	99	0.004	0.006	0.130	0.130	0.002	0.003			3.8	3.8	
10	January 8	1:15 p.m.	71	52	52	20	20	5	5	1E	1E	10.7	11.0	97	100	0.002	0.002	0.136	0.134	0.003	0.003	0.12	0.12	3.7	3.8	
11	January 9	2:10 p.m.	59	51	51	20	20	5	5	1E	1E	10.7	11.3	96	101	0.002	0.002	0.124	0.126	0.002	0.003	0.12	0.12	3.8	3.8	
12	October 8	1:00 p.m.	80	76	74	35	35	5	5	3E	2E	6.3	8.2	75	95	0.026	0.026	0.128	0.132	0.001	0.001			3.1	3.3	Water in transition; very
13	October 9	11:00 a.m.	79	74	73	35	35	5	5	2E	2E	6.5	8.4	76	97	0.028	0.028	0.136	0.136					3.4	3.4	slight taste at first,
14	October 11	10:00 a.m.	74	74	74	35	35	5	5	2E	2E	6.5	8.3	76	96	0.020	0.020	0.112	0.112	0	0			3.1	3.0	finally no taste.
15	October 12					35	35	5	5	2E	2E					0.014	0.014	0.114	0.114							
16	October 13					35	35	5	5	2E	2E					0.024	0.022	0.128	0.126							
17	October 15					35	35	5	5	2E	2E					0.022	0.022	0.128	0.128							
18	October 16	1:30 p.m.	60	67	66	30	30	5	5	2E	2E	7.6	8.7	82	93	0.012	0.012	0.120	0.120	T	T			3.1	3.2	
19	October 18	9:55 a.m.	64	67	66	35	35	4	4	2E	2E	7.6	8.9	82	95	0.016	0.016	0.118	0.118	T	T	0.12	0.12	3.3	3.2	
20	October 22	1:30 p.m.	67	67	64	35	35	4	4	2E	2E	7.8	9.3	84	97	0.016	0.016	0.116	0.122	0.001	0.001	0.10	0.10	3.4	3.4	
21	October 23	1:30 p.m.	62	65	63	100	100	5	5	2E	2E	7.4	9.3	78	95	0.016	0.016	0.118	0.118	0.001	0.001	0.14	0.14	3.8	3.8	
22	October 24	1:30 p.m.	66	64	62	190	190	5	5	2E	2E	7.6	9.4	79	95	0.018	0.018	0.126	0.130	0.001	0.001	0.12	0.12	3.9	3.9	
23	October 26	1:30 p.m.	59	62	61	230	230	10	10	2E	2E	7.2	9.2	73	93	0.018	0.018	0.162	0.162	0.004	0.004	0.11	0.11	5.4	5.3	
24	October 29	1:30 p.m.	68	62	62	135	135	10	10	2E	2E	7.2	9.1	73	92	0.022	0.022	0.146	0.146	0.004	0.004	0.14	0.14	4.7	4.7	
25	October 30	1:30 p.m.	50	61	58	125	125	10	10	2E	2E	7.4	10.2	74	100	0.020	0.020	0.150	0.150	0.004	0.004	0.15	0.15	4.3	4.3	
26	November 1	1:45 p.m.	46	59	57	130	130	10	10	2E	2E	8.2	9.6	81	93	0.016	0.016	0.144	0.146	0.001	0.001	0.13	0.13	4.3	4.3	

no distinction could be made. However, when the taste is rather pronounced slight differences could be noticed.

Free Ammonia; albumunoid ammonia; nitrites; nitrates; and oxygen consumed. There are some slight differences noted, sometimes a gain, sometimes a loss, but all the departures from the original water are so small that they could come within the personal error of the analyst. In the case of oxygen consumed, the evidence bears out Frankland's statement previously noted, "That organic matter is not gotten rid of by exposure to air for a few seconds."

Dissolved oxygen. This is the only phase of aeration that shows any definite results, and it is only obvious that such results should be obtained.

Evaporation. We have no means of knowing the evaporation losses accurately, which no doubt are considerable in the hot summer months, when temperatures from 100 to 110 are common. Pan evaporation figures are available, but are not applicable to this.

If an observer stands on the leeward side of our aeration basin, a very decided odor is noticeable. It is very evident that something is being removed by the process and that it is of a gaseous nature.

From table 1 it will be seen that taste and dissolved oxygen are closely related. This is in line with the experiences of Mr. F. H. Waring in his study of tastes and odors in Ohio water supplies (JOURNAL, Vol. 10, No. 1, January 1923) wherein he states "the decrease of the dissolved oxygen constituent is the most important single factor entering into the intensity of these earthy tastes and odors."

From our experiences at Forth Worth, it appears that, when the dissolved oxygen in the raw water is around 50 to 60 per cent saturation, we have noticeable tastes. When it is near 70 to 80 per cent the taste is slight, and when it reaches 95 to 100 per cent there is no taste.

In line with the observations we have made we would conclude that, in the aeration of water, several factors should be considered. These are:

The exchange and removal of obnoxious gases. It goes without saying that the ideal is that which breaks the water into the finest particles, due allowance being made for wind action to dissipate the removed gases.

Chemical and biological oxidation are necessarily slow and the time factor is of importance.

In securing the maximum biological action the logical place to aerate the water is before filtration, since organisms of various sorts enter this action, and after filtration and sterilization they are entirely absent or at a minimum.

A study of the oxygen content at various depths of the raw water reservoir is of value, and intakes should be so constructed to take advantage of any beneficial variation. This phase of our particular problem has not yet been studied, but we believe that it offers some possibilities, and that if we could take advantage of the variations we believe exist, we feel that we could eventually produce a water entirely free from taste at all times.

CONTROL OF SLUDGE LEVEL IN SEDIMENTATION BASINS

By L. B. Mangun[1]

The Missouri River is the source of Kansas City's water supply. But the "Big Muddy" is only partially responsible for our turbidity troubles. The chief cause of difficulty has been inadequacy of purification facilities. The plant has been added to from time to time, usually providing rather tardily only for immediate needs, with little or no provision for future growth of the city. Consequently, during most of the time in the past the plant has been overloaded. This policy is now abandoned. The plant is in process of being doubled in size, which ought to take care of the city for several years to come.

Only a few decades have passed since raw river water was served the inhabitants, and many seemed to like the cloudy liquid. Perhaps they had acquired a taste for it. We have no less an authority than Mark Twain for the statement that after a citizen would draw a glassful from the faucet, if perchance it stood long enough to settle somewhat he would stir it up with a spoon before drinking.

However that may have been, the situation has changed to a degree. While hardness is not much observed, leastwise not complained of, nor a turbidity of 10 to 15 parts generally remarked, a little higher than that will loose a flood of complaints. During 95 per cent of the time for several years past the filters have delivered water so clear that the people seem to have been educated thereby to a greater fear of turbidity than of anything else that the water might contain.

It is during the remaining 5 per cent of the time that we have had our turbidity troubles. These periods may occur at any time between March and November, usually lasting from several days to over two weeks. During the year 1923 there was a period of two days of turbid effluent in June, another of eight days in July, and a third of eighteen days in October.

[1] Chemist in Charge, Water Purification, Kansas City, Kans.

The regimen of the Missouri differs from other rivers of the region because of the vastly greater extent and the variety of its watershed. Rains and thaws in the north-central states produce a more or less fitful initial spring rise starting in February and lasting until the middle of April. After this a gradual subsidence may be expected until the so-called June rise, caused by melting snows in the mountainous states of Wyoming and Montana. The volume of run-off in June is usually greater than during any other month of the year. The June and subsequent rises are less rapid than in the early spring, when a rise of 10 feet may occur in forty-eight hours. But turbidity conditions are less stable. In other words, during June and the latter half of the year the stream is not subject to such sudden changes in height as during the first part of the year, whereas the amount of turbidity and suddenness of change, or flashiness, of turbidity is usually greater after June 1 than before.

The character of the suspended material carried by the waters from the upper course differs greatly from that present in run-offs from the middle course of the river. The latter is dark in appearance, varying from brown to black, depending upon the proportion of humus to sand and clay. This water is fairly amenable to treatment. The size and density of a large percentage of the material is such as to give masses sufficiently ponderable to settle out in the roughing basins. A retention period of twelve minutes in the preliminary settling basins will reduce this turbidity usually 15 to 20 per cent, a retention of twenty-four minutes 50 to 60 per cent, and if the basins are so arranged as to make a longer preliminary period possible, as Gilkeson does at the Kansas City, Missouri, plant, a 90 per cent reduction may be obtained before treatment with coagulant.

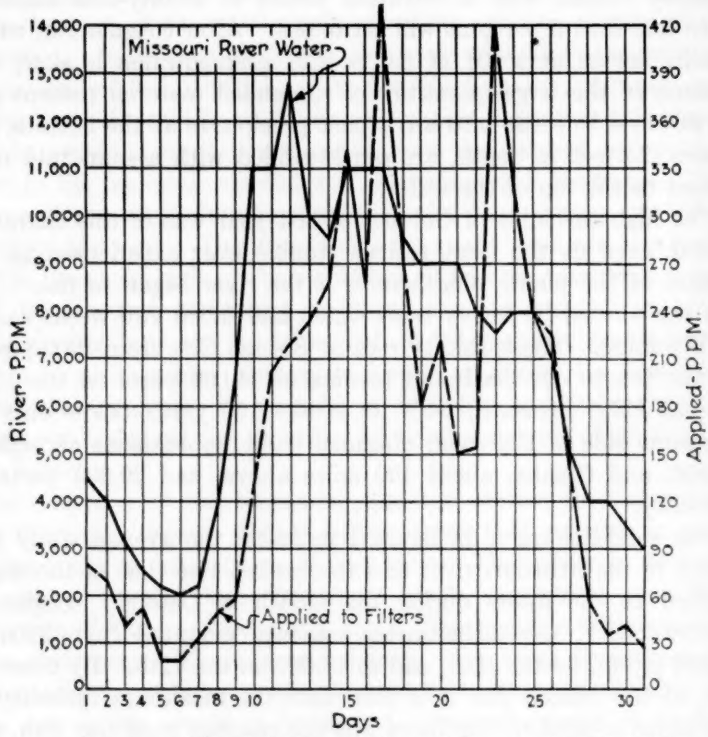
But the material originating nearer the head waters of the Missouri is far more difficult to handle. It is light-yellow in color, of low specific gravity, and finely divided. The coefficient of fineness, compared with the silica standard, was 0.807, as calculated from the results of some sedimentation experiments by Mr. Geo. M. Darby of the Dorr Company, and 0.840, from experiments by Mr. W. Donaldson. Rather oddly, however, in the water it has a somewhat more flocculent than granular or colloidal appearance, not unlike alum floc. In fact, it would sometimes be difficult to tell by observation whether it had been coagulated or not. In the pre-

liminary basins, with a retention period of twenty-four minutes, often less then 5 per cent will settle out. After coagulation, which readily occurs at a pH of 8.0 to 8.2, sedimentation is slow, and because of the large quantities of suspended material present and its slowness to settle into a compact precipitate at the bottom, the basins, 25 feet in depth, are quickly filled with a semi-fluid mud almost to the top of the water.

The high turbidity of October of last year was of this character and it gave us the most serious trouble ever experienced in the history of the plant. On October 7 the river began to rise. The rise was caused by heavy rains which had fallen two weeks earlier in Wyoming. The turbidity rose at Kansas City from 1900 p.p.m. on the 6th to our maximum reading of 14,000 parts on the 12th. Kansas City, Missouri, with its intake 100 yards below ours on the same side of the river, obtained turbidity readings as high as 18,000, and Omaha, about 190 miles above, had 20,000 parts of turbidity.

The solid-line curve in figure 1 indicates the average daily turbidity of the Missouri river and the broken line that of the water applied to the filters during the month of October. Beginning on October 7, the turbidimeter readings mounted from 2200 to 11,000 p.p.m. by the 10th, and to 13,000 on the 12th. By observation of the broken line it is seen that the maximum turbidity of the water applied to the filters was not reached until the 17th, five days later. The explanation of this is that the settling basins required that much time to fill with mud. The rapid falling off in turbidity of the applied water immediately after the 17th was due to the fact that the pumping rate was cut approximately a fourth by taking water from Kansas City, Missouri, in addition to reducing consumption to the minimum by lowering the pressure. The latter measure had been applied since the 11th.

The largest settling basin, an eight-million gallon basin constituting half of our entire settling capacity, has two sewer valves for flushing out sludge. During all of this time it was extremely difficult to do flushing, as every time one of the valves was opened the increased velocity of the water through the basins to make up the loss would bring up the turbidity of the effluent very rapidly. Nevertheless, almost every day, when the pumping was lowest, usually after midnight, as much flushing was done at these valves as was thought possible. However, on the 22nd, when soundings



Average Daily Turbidity of Missouri River and Applied Water for October 1923

FIG. 1

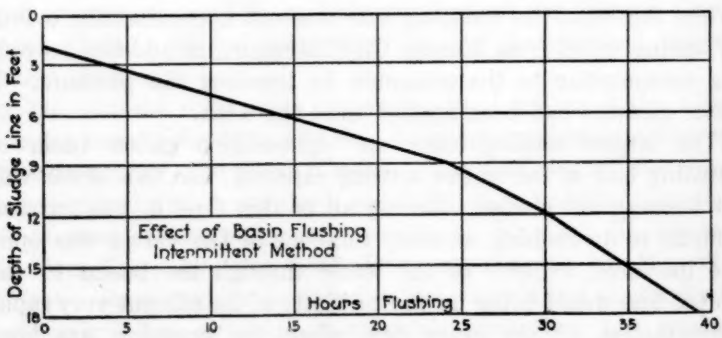


FIG. 2

showed sludge reading 28,000 turbidity within 2 feet of the surface of the water, in desperation we opened the two sludge valves, one at a time, for a period of five hours. The opening was about 30 square inches, which would flush out a total of nearly a million gallons of water, or about one-eighth of the basin capacity. The peak in the turbidity curve on the 23rd followed, and no appreciable lowering of the sludge-line in the basin was observable. The neighboring plant of Kansas City, Missouri, had a similar experience. Their valve was opened sufficiently to flush out ten million gallons of water from one basin without obtaining any significant removal of the mud which nearly filled the basin.

Continuous flushing draws out only a column or cone of sludge directly over the valve immediately after opening, and thereafter, as long as the valve remains open, the best water is drawn off from near the surface, with relatively small amounts of the more viscous sludge strata being drawn upon. This fact appeared to us as a possible explanation of the results described above.

Pursuant to this line of reasoning, on the 25th, we stationed a man at each of the two sludge valves. They opened one valve at a time, alternating every five minutes. In this way each valve was open five minutes and then remained closed five minutes. If it was true that a cone of mud was withdrawn only upon opening the valve, it was expected that closing the valve frequently would permit the sludge stratum to become level again, replacing that which had been removed over the valve. The effluent weir from the basin in question is about 2½ feet below the surface of the water. Immediately following our attempt at continuous flushing on October 22, soundings at the center of the basin showed 28,000 p.p.m. turbidity 2 feet from the surface, practically the same as before flushing. At a depth of 3 feet the turbidity was 50,000 p.p.m. and at 6 feet, 110,000 p.p.m. After twenty-four hours of continuous flushing, alternating the opening of the two valves every five minutes, the sludge-line was lowered 9 feet, and after thirty-six hours it was lowered a total of 17 feet.

But it still remains to be definitely determined whether one kind of flushing is more effective than another in removing sludge more quickly and in larger amount in proportion to the quantity of water wasted; whether it should be continuous or intermittent, long or short intervals, rapid or slow.

Although slow continuous flushing should satisfactorily meet

the same conditions and give about the same results as intermittent opening of the valves in the instance cited, this did not seem to be borne out by later experiments. However, no opportunity presented itself to try it under similar conditions until April, when we encountered the first high river turbidity of this year.

Continuous flushing was not attempted in April. The intermittent was resorted to at once to determine its effectiveness under conditions of continued high turbidity. The results, as shown in table 1, fulfilled all that we had hoped for in the handling of very high turbidities, although we learned that more of it was necessary than we had anticipated.

TABLE 1

Data for flushing basin

April and May, 1924

DATE	MODE OF FLUSHING	LENGTH OF TIME	OPENING OF VALVE	DEPTH OF SLUDGE LINE	RIVER TURBIDITY
		hours	*square inches*	*feet*	*p.p.m.*
April 14		0	0	7½	7,000
April 15	Intermittent	15	20	9	7,000
April 16	Intermittent	12	10	10½	7,000
April 17	Intermittent	12	10	10	8,500
April 18	Intermittent	8	25	7	8,500
April 19	Intermittent	16	25	7	9,000
April 20		0	0	3	10,000
April 21	Intermittent	20	35	4½	10,000
April 22	Intermittent	24	45	6	10,000
April 23	Intermittent	24	45	8	10,000
April 24	Intermittent	24	50	10	9,500
April 25	Intermittent	24	50	12	8,000
April 28 to May 5	Continuous	96	25	14	3,500

Table 1 shows that flushing twelve to fifteen hours a day was sufficient to lower the sludge line with a river turbidity of 7000. But with eight hours flushing on the 18th and a river turbidity of 8500 the sludge-line raised 3 feet, and on the 19th, with sixteen hours flushing and 9500 turbidity, the sludge-line remained stationary. On the 20th, which was Sunday, no flushing was done. The river turbidity was 10,000 and the sludge-line raised 4 feet, or to within 3 feet of the top. Under this condition the effluent from the basin reached 900 parts turbidity, and the water applied to the filters 450, with a slightly turbid filter effluent.

Beginning with Monday morning, the 21st, the basin was flushed by the intermittent method continuously for six days, and although the turbidity remained at 10,000 until the fourth day, the sludge-line was lowered to ten feet and the filter effluent cleared.

The second column of figures in table 1 shows the area of opening of the sludge valves. There is no meter on the river supply and the amount of water actually wasted is unknown. Beginning Tuesday, the 22nd, Kansas City, Missouri, flushed out approximately a third of their total pumpage, by the continuous method, with excellent results as to the lowering of the sludge-line.

In the handling of waters of high turbidity flushing is of vital importance. We intend to continue this study of flushing under more favorable conditions to determine if there is a difference in efficiency in flushing by different methods. Next month two new settling basins of 20,000,000 gallons capacity will be put into service. The sewer from these is equipped with a sampling device by which we shall be able to determine at once and with some degree of precision the results we get from any kind of flushing.

THE NEW JERSEY WATER SUPPLY PROBLEM[1]

A. Review

By G. L. Hall[2]

The authors were employed "to make investigation and report upon the future water supply of Bayonne" so that the development of the Ramapo River could be determined in advance of other projects.

In 1923 the municipal authorities had to choose between asking the North Jersey District Water Supply Commission for supply from the Wanaque River project and asking the Department of Conservation and Development for 50 m.g.d. from the Ramapo River, this latter development to be under the sole control of Bayonne. Present authorities must consider above conditions and must now ask permission of the new North Jersey Commission either to become a partner in the Wanaque project or to have the Ramapo project developed primarily for the use of Bayonne. The North Jersey District Water Supply Commission stated at a hearing in November that it would allot to the city 20 m.g.d. or about one-fifth of the yield of the Wanaque. If present rates of increase in consumption are maintained the supply would have to be augmented by other sources by 1933. Special study is given to the Ramapo developed by reservoirs and by leading an aqueduct through Bergen County and assuming that Bayonne would consume two-thirds of the water and bear two-thirds of the costs. The supply might be sufficient for the city until about 1945. It would be wise, however, at present to plan construction for the period ending 1960. As Bayonne's contract with the East Jersey Water Company expires in 1929 and new works might not be available by this time, consideration should be given to the purchase and improvement of the Little Falls supply. The broad question of the water supply of Metropolitan New Jersey

[1] Report on Water Supply, Bayonne, N. J., 1924, Weston and Sampson. Containing also Report of Citizen's Committee of Twenty and of its Consulting Engineer, Weston E. Fuller.

[2] Division Engineer, State Department of Health, Baltimore, Md.

was considered from the viewpoint of Bayonne, which led to outline studies of streams from the Raritan to the Delaware Rivers as possible sources of supply and of the possibilities of the use of interstate waters by treaty.

The 1960 population of 200,000 maximum is based upon the assumption that the port of Bayonne will be developed and that for a considerable period the rate of growth will not decline appreciably. The high per capita water consumption of 163 gallons, which includes Kearney Meadows, is due to the presence of large industries. Should the same kinds of industries occupy the additional area provided for in the port development an even higher figure could be expected.

Ramapo River, is an interstate stream. Approximately one-quarter of its catchment area lies in New Jersey and three-quarters in New York. The population density is approximately 92.7 per square mile. Suffern, in New York, is the only village of any size discharging sewage into it. There are, in addition, a number of smaller settlements and factories emptying wastes into the Ramapo, but these do not present any particular difficulty.

In the report of Hazen, Whipple and Fuller to the Department of Conservation and Development, on Water Resources of New Jersey, the daily safe yield of the Ramapo, with a storage reservoir of 6,300 million gallons capacity above Oakland, is estimated at 61 million gallons 15 m.g.d. of which must be let down to satisfy prior rights, leaving 46 m.g.d. available. With the Ramapo fully developed above Oakland by the construction of a dam on the Mahwah River at Union Hill and diversion works above Tuxedo to convey water from the upper reaches of the Ramapo and several small streams, into the Mahwah reservoir, it is estimated that a safe net yield of 115 m.g.d. could be secured. The only objection to this development would be its interstate character. Mr. Clyde Potts at one time suggested the formation of a stock company to acquire the rights on this stream. Such a company would have to apply to the New York legislature for a charter which move, according to past experiences, would occasion some difficulty. Probably more hope lies in an interstate Tri-State Commission which would consider how the interstate waters might be utilized to the best advantage in both states. (cf. Journal, February, 1925, page 160.) New York City might be willing to surrender its rights in the Wallkill and Ramapo sources for New Jersey's rights in the Upper Delaware.

Should New York decide to develop the Upper Ramapo and the Mahwah for its own use, the safe yield at Oakland might be reduced to about 30 m.g.d. which would be inadequate for Bayonne.

To improve the quality of the Ramapo water the following remedies would be required: (1) to convey sewage from Suffern and wastes from the gas plant below the dam through a tight sewer beneath the reservoir; (2) protect water in the reservoir by purchase of a strip of land around it; (3) proper disposal of sewage now discharging into the Upper Ramapo and Mahwah Rivers; and (4), aeration and filtration of the water before discharge into the aqueduct. With these improvements the water would compare favorably with waters obtainable from the northwestern part of the State. Various methods of conveying water to the city are: (1) by aqueduct through Bergen County; (2) by aqueduct through Pompton Lakes and the Watchung Mountain; (3) by Wanaque aqueduct enlarged, and (4) through Little Falls. Each supply line is discussed in detail and the merits and disadvantages of each are pointed out.

The Wanaque project which is now under discussion is referred to in relation to supplying Bayonne. In this development it is proposed to build a dam at Wanaque storing about 27,595 million gallons with a catchment area of 94.4 square miles. Winter population on the area is low and while there is a decided increase during the summer months, the character of the soil and the self-purification afforded by the long storage period—more than eight months—will produce a water superior to most surface waters. The supply will cost about $240,000 per million gallons daily to develop, which makes it not only the best, but the cheapest, source of supply for most cities in the Metropolitan District.

Additional sources of supply in the northwestern sections of the state north of Plainfield are available, but no accurate cost estimates were made on these developments for Bayonne. The development of these supplies was suggested by Hazen, Whipple and Fuller.

An examination was made of the two 30-inch and the 48-inch pipe lines from the Arlington gate house to Bayonne. On account of the deterioration of the two 30-inch lines, which are laid across the Hackensack meadows, it will be necessary to replace about 17,000 feet with one 48-inch line, preferably of steel pipe on account of the present high cost of cast-iron pipe.

Cost estimates of the various projects are given in detail. The initial costs of development per million gallons are as follows:

	MILLION GALLONS DAILY	INITIAL COST PER MILLION GALLONS
Wanaque, Bayonne's share	20	$225,000
Ramapo-Wanaque	45	258,000
Ramapo-Wanaque, full development	116	258,000
Ramapo-Bergen County	45	360,000

The authors recommend: (1) Bayonne "abandon all attempts to acquire exclusive rights in the Ramapo or to build works for its independent supply from that source;" (2) "the city accept the offer of 20 m.g.d. from the Wanaque source," which will suffice until 1932; (3) the purchase of the Little Falls plant of the Passaic Consolidated Water Company; (4) the city use whatever influence it has against "multiplying aqueducts in northern New Jersey;" (5) since Bayonne will require 40 m.g.d. by 1960, it should stipulate in the agreement when its needs exceed the 20 m.g.d. alloted in the beginning, that they shall be met from sources not yet developed; (6) because of the lower cost of the Ramapo in comparison with probable costs of developing the Upper Passaic and Upper Raritan Rivers and since to delay developing these sources would be less costly than to delay the Ramapo development, Bayonne should support this project which would provide for its full development by interstate agreement or otherwise; and (7) the city "support any reasonable plan which will pool the interests of the various municipalities."

Prof. Weston E. Fuller was asked by the Citizen's Committee of Twenty to advise them "whether it will be better to obtain the future water supply for Bayonne from the Wanaque River or from the Ramapo River." This study took into consideration the large amount of data available from previous reports and investigations. Estimated costs of construction to Bayonne of the various projects per m.g.d. are as follows: Ramapo development with reservoir at Oakland and Bergen County aqueduct—$629,000; full development of Ramapo including replacements and repairs to meadow lines and additional river crossing—$468,000; Wanaque supply to Belleville, including connection from Belleville to Bayonne's pipes—$252,000; Stony Brook with pipe across Newark Bay to Bayonne—$379,000; Wanaque plus Ramapo with Oakland reservoir using enlarged Wanaque aqueduct, including replacement and repairs to meadow lines and additional river crossing—$309,000; Wanaque plus Stony

Brook with Newark Bay crossing to Bayonne—$303,000, and Wanaque plus Stony Brook with Newark Bay crossing, and enlarged reservoir and other works in consideration of future supply—$318,000. These estimates all include interest charges during construction. It is concluded that any development of the Ramapo as an independent source for Bayonne with separate aqueduct will be very costly; the Ramapo can be economically developed along with the Wanaque with common aqueduct and by taking advantage of the large natural flow in the Ramapo; when the Wanaque supply becomes insufficient for Bayonne additional water can be obtained from development of the Upper Passaic and branches of the Raritan at reasonable cost and at a much less cost than the independent development of the Ramapo; if the Ramapo is to be used to supplement the Wanaque in the future, the Wanaque aqueduct should now be built of sufficient size to carry the joint supply; the Wanaque supply obtained by joint development with other cities is the cheapest supply for Bayonne; and, there are economical and satisfactory ways of securing additional supply when the amount of water allotted to Bayonne becomes insufficient. The recommendations are that (1) Bayonne enter the Wanaque project; (2) an agreement be made between the municipalities securing water from the Wanaque so that those growing rapidly shall be allowed additional water beyond their allottment after compensating those municipalities which do not need it; (3) a decision be made as soon as possible whether or not the Ramapo will be developed in conjunction with the Wanaque as an additional supply for the district so that the Wanaque aqueduct can be made of sufficient capacity; (4) if possible, Bayonne come to an agreement with the municipalities participating in the Wanaque project relative to future joint undertakings to meet the demands of the district when the Wanaque shall prove to be insufficient; (5) if a satisfactory agreement outlined in (4) cannot be reached, Bayonne protect its interests by taking such steps as may be necessary to obtain an additional supply from Stony Brook or such other sources as are available; and (6) Bayonne use its influence toward bringing about the development of the remaining sources of supply in the state under the control of a state commission or some other body with adequate powers.

THE WATER DEPARTMENT AS A PUBLIC UTILITY CONTROLLED BY A WATER BOARD AS OPPOSED TO ITS REORGANIZATION UNDER THE CONTROL OF A DIRECTOR OR BOARD OF PUBLIC WORKS[1]

The success of any business enterprise depends upon its conformity to the fundamental laws of political economy. The City Government assumes the rôle of a public corporation when it undertakes to market a commodity or service. The community is the consumer and the corporation is maintained by public funds and operated without profit. That department of the City Government becomes a business entity when specialization of labor and function becomes necessary for the production of a single economic good or utility.

Private corporations form subsidiaries because they recognize the gain in efficiency that comes from self-contained organization and organize such subsidiaries with complete functions.

The Water Department fulfills the requirements of this business entity—its labor and function is specialized, its product a single economic utility which is the result of the manufacture of a material good from the raw product or free good, to which is added personal service, before it is finally consumed after having been delivered by the department to the consumer. It is then a public utility, entirely individual in character, and should retain this individuality in the City Government in conformity to both legal and economic law. The United States Supreme Court, and other courts, have held that, when a municipality engages in the water business, it conducts a "commercial enterprise" and is subject to the same rules at law as a private company engaged in the same business.

[1] Summary of Report on the Organization of the Water Department, submitted to the Committee on Efficiency and Economy by the Water Board, City of Baltimore, V. Bernard Siems, President, 1924. This brief was submitted by the Water Board in disagreement with the tentative plan of the Mayor's Committee on Efficiency and Economy, which provides for placing the Water Department under a Director of Public Works. It discusses an important problem in municipal water department management.—*Editor.*

The entity of the Water Department as an individual public utility depends upon:

1. Its function.
2. Its contact with the public, the taxpayer consumers.
3. Its size.
4. The requirements of its service.
5. The unity of function which is necessary to guarantee the fulfillment of its service requirements.

As to its function as a utility conducting a commercial enterprise, the Water Department is engaged solely in the manufacture, sale and delivery of one finished commodity—pure water. Its revenue is derived entirely from the sale of this commodity and is not derived, as is the case of the other departments which are not public utilities, from the general tax levy.

As regards its contact with the consuming public it has the power to fix rates and charges and to make regulations governing service, as well as those regulations necessary to insure a plentiful supply of pure water. In the sale and delivery of its commodity, its employees are in direct contact with 165,000 purchasers.

As to its size the Water Department payroll includes approximately 1000 employees, and a recent valuation of the plant under the control of the Water Board places it at approximately $45,000,000 and the capital invested is on the increase. The Department operates and maintains approximately 1450 miles of water mains and conduits, besides extensive impounding works, purification works and pumping stations, all of which is specialized equipment used by no other department. The Department has under its direct control approximately 10,000 acres of land and exercises police control over approximately 310 square miles of watershed outside the City.

Regarding its service requirements, the Department is required under the Baltimore County Metropolitan Act to supply water to consumers outside the corporate limits and is subject to the jurisdiction of the Public Service Commission of Maryland, thus falling into the category of a private corporation. The nature of its utility makes it essential that the Water Department be in a position to maintain continuity of service, more so perhaps than in the case of any of the privately operated utilities and it must provide constant fire protection for the entire area of the City and Metropolitan District.

The inherent unity of the Department is selfevident when one considers that its employees are highly specialized professional workers, highly specialized artisans and skilled and unskilled laborers, whose duties are confined to the requirements of constructing, operating and maintaining a satisfactory water supply. There is no overlapping of function between the Water Department and any of the City departments. The service which the Water Department must render can only be guaranteed through complete control of all of the factors of this service, intimate control of its machinery of production, as well as its accounting and cost-keeping personnel. In order to have efficient operation, it is necessary that we have, through our own accounting personnel, a close check available at all stages of any project, upon the cost of individual operation and production units as well as an accurate check on the receipts for the service rendered—such accounting and cost data as we now have always at hand prepared by accountants with specialized knowledge and experience in water works. Nor can any unconnected bureau discharging any function associated with the service, defined in the foregoing obligations of the Water Department, operate with that degree of satisfaction to the consumer that would result from this control remaining in the hands of those directly responsible for the conduct or operation of the Department.

Centralization reaches the marginal limit of utility through the law of diminishing returns, and this applies very early in the case of City Governments attempting to control public finances and public service functions, and has led to the creation of subsidiary boards with broad powers, especially in the control of water supplies.

According to general knowledge of the organization of municipalities along the lines of both the centralized Mayor-Council plan and the City Manager plan, the Department of Water Supply is always found separate and distinct from the Department of Public Works even when a plan is adopted which is very similar to that proposed for Baltimore. If this fact is disregarded it may be predicted with reasonable certainty that at some period or other attempts will be made to manipulate water rates and regulations directly with the tax rate.

Under present conditions the City is obligated to perform certain functions in the counties. In performing these functions the Water Department has been able to conduct its work with dispatch be-

cause the head of the Water Department has had the power to confer directly with the County authorities and also to make regulations without the delay necessarily incident to the submission of these matters to a Director or Board of Public Works. If the identity of the Water Department were lost, and the cost of service for the reasons shown thereby increased in the counties by a lowering in efficiency, it is quite probable that the Public Service Commission would compel the City to absorb these excess charges out of its tax rate, and to supply the County Commissioners at a reasonable cost, that is, at a cost comparable to that now properly chargeable for such work or service.

In the event of the subordination of the Water Department to a Board or Department of Public Works, it may be further predicted that the present promptness of service rendered by the Department to complaining taxpayer-consumers and county consumers would be greatly hampered by the lack of control over its necessary transportation facilities. Machinery and vehicle equipment are now kept at a high state of efficiency in the Department through prompt repairs and through the absence of routine which would operate against prompt attention. By virtue of the present material yards and shops the Department is enabled further to repair quickly defective mains and pumps and even employ its same force to manufacture, at a fraction of the market price, certain of its specialities—such as manhole vaults, etc. Moreover, a review of the amount of material moved and the traffic management of Department motor equipment confirms the efficiency of the present plan of complete control over the upkeep and movement of this equipment.

The various organizations of the City employ corporate functions only insofar as these functions are granted by express legislation of the State, and, in fact, rather than curtail the present powers of the Department, it seems essential to efficiency and economy that these powers be broadened.

It seems advisable then to request from the state legislature such powers as will enable the Water Department to operate more nearly as a true public corporation. The personnel of the Water Board, composed of seven members including the Mayor (ex-officio), the Comptroller (ex-officio) and the Water Engineer should be direct representatives of the taxpayers of the City, the common and preferred stockholders in the municipal corporation, one of the non-ex-officio members to be appointed each year for a term of five

years. The Board should have control over bond issues designed expressly for the improvement of the water supply, fix and control rates, collect revenue and perform such other duties and make such regulations as are directly essential to the operation of the Department. The rates would be fixed at such a level that they would not alone provide for the operation and maintenance of the system, but also supply the interest and sinking fund payments necessary on bond issues, which method of financing is provided for in the creation of the Baltimore County Metropolitan District. These rates would be a direct index to the efficient operation of the Department and would give the voter of the City an opportunity to criticise its operation and to express his approval or disapproval of its management at the polls.

WATER TREATMENT AND LABORATORY CONTROL[1]

By Wilfred F. Langelier[2]

In this brief paper the writer wishes to advance certain arguments in favor of laboratory control of water treatment processes, and to indicate how, in his opinion, this control may be most effective. It is undoubtedly a fact that there are very few water supplies which, without some form of treatment, are entirely satisfactory for domestic and industrial uses. Surface waters are usually subject to bacterial contamination and therefore require disinfection. If the waters are turbid, filtration is desirable. If surface waters are subject to neither bacterial contamination nor turbidity, the water is probably subject to algal growths and must occasionally be treated with an algaecide to prevent their further development. Ground waters often contain iron, the symptoms of which are well known. The presence of traces of manganese may cause incrustations in service pipes. Ground waters may be excessively hard and, although in the case of any given supply there may be no evidence of a demand on the part of consumers for a softer water, it does not follow that softening the supply would not result in greater satisfaction and economic gain to the consumers. Many water supplies are excessively corrosive and are the cause therefore of a great amount of damage to distributions systems, service pipes and plumbing fixtures. The simple expedient of aeration, or treatment with a small amount of lime, would in most cases adequately correct this condition.

In the water treatment plants of most recent design, the tendency is toward additional steps in processes of purification that were formerly considered adequate. The carbonation of softened waters, double aeration of certain filtered waters, and the use of chemicals to remove chlorine tastes are examples of this very noticeable trend.

In the past we have stressed the sanitary and aesthetic importance of water purification; in the future it is to be hoped that we shall lay equal stress upon the economic aspects.

[1] Presented before the California Section meeting, October 24, 1924.

[2] Associate Professor of Sanitary Engineering, University of California, Berkeley, Calif.

Granting that most waterworks officials find it necessary or desirable to treat their supply in one manner or another, the question arises as to whether there is any necessity for laboratory control, and if so, what should be the nature and extent of this control. The larger waterworks usually find it desirable to employ a chemist or biologist and conduct a well-equipped laboratory. Experience shows that in these plants the laboratory is a very valuable asset and its cost is very slight in comparison with the benefits derived. The smaller waterworks, however, often neglect this important feature of plant operation. This is particularly the case in plants wherein the principal treatment consists of chlorination. It is to be regretted that such a valuable water treatment process as chlorination should be so unpopular with water consumers. This growing prejudice is due, of course, to the very objectionable tastes produced in waters which are improperly chlorinated. Due to the fact that perfect chlorinating apparatus has not yet been developed, it must be admitted that even the most elaborate laboratory control will not entirely eliminate the occurrences of tastes in chlorinated water; it is not to be doubted, however, that the frequency of such occurrences could be materially diminished by such control. The amount of chlorine required to disinfect different water supplies may vary between the wide limits of one to ten pounds of chlorine per million gallons of water. A water which requires only the smaller amount would, in all probability, taste badly if treated with even one-half of the larger amount. Likewise, a water requiring the larger amount would be imperfectly disinfected with twice, or three times, the smaller amount. In any one supply, the chlorine demand value may change materially with the season, but suitable control tests, that are entirely adequate to determine the effectiveness of chlorine treatment, have been devised and can be carried out without the services of a trained laboratory technician.

In the matter of coppering a reservoir, to eliminate tastes and odors due to algal growths, it is the usual practice to apply the treatment only after the trouble has developed, whereas, the more logical method would be to anticipate development of algae and apply corrective measures in time to avert the trouble. A record of algal growths occurring in a reservoir throughout a series of years is of much value in forecasting the probable time of development and, thereby, the proper time or frequency of dosage.

The extent of laboratory facilities which a waterworks official

is justified in providing will depend upon local conditions. In general, the larger the plant and the more complicated the treatment problems, the greater will be the need for suitable facilities. In this connection, the advice of state board of health officials, or other competent authority, should be sought. The writer is very strongly of the opinion that in any waterworks laboratory, even when a trained chemist is placed in charge, simple control tests should be made by the operator or person in direct charge of the various treatment processes. The operator of a chlorinator, for example, is less likely to permit the machine to get out of order or to carelessly over- or under-dose the water, if he has some sort of a measuring stick that he can apply to ascertain the effectiveness of the treatment. An operator, who is incapable of making simple control tests himself, is usually found to be incapable of keeping the chlorinator in repair and of following instructions as to dosage. If he does not have time to make such tests, he very likely does not have time to keep the machine in repair and will not faithfully follow instructions as to dosage.

As indicative of the control tests which I have in mind, I will mention only two, those of most general application. One may be used in connection with chlorination and the other in connection with the treatment of reservoirs with copper sulphate.

The simplest test which can be used in controlling the dosage of chlorine is the ortho-tolidin test. This test consists simply of adding a few drops of a tolidin reagent to a sample of the treated water. The intensity of the yellow color which develops is a measure of the amount of free chlorine remaining in the water at the time of testing. A definite excess of chlorine at a definite interval after treatment is a fair criterion of the effectiveness of disinfection, but, in general, this test is not sufficiently refined and in the absence of supplementary bacterial tests, it does not appear to the writer to be adequate protection against over-dosing. The importance of chlorination and the practical difficulties in properly proportioning the dosage to prevent taste and at the same time secure adequate disinfection, warrant a more refined test than the ortho-tolidin-procedure. In the larger plants, complete bacterial examination with supplementary tolidin tests by the operator are desirable. In the smaller plants, where usually the raw water is of less dangerous character and where it is not practicable to employ the services of a chemist, the writer recommends the making of simple bacterial

counts of the raw and treated water. This procedure is not difficult and the results are positive. A correct interpretation of the results is based on the fact that the disinfecting action of chlorine is selective and that bacteria capable of transmitting disease are more readily killed by this disinfectant than are the other bacteria commonly associated with them. If daily bacterial counts of the raw and treated water show consistently a marked reduction, say 90 per cent, in favor of the treated water, it is fair to conclude that the disinfected water is safe. In this way the minimum dosage which will yield the desired result may be readily ascertained. A description of this method of chlorination control, with full instructions for the plant operator, has been issued in pamphlet form by the California State Board of Health. Fifteen or more small waterworks in this state have been using this method of control for over a year and with apparent satisfaction.

The examination of reservoirs for algal growth is ordinarily attempted only by the laboratory technician. The Sedgwick Rafter procedure, which is in general use, requires, first, that the organisms be concentrated by means of a specially designed filter, and secondly, that the organisms be counted with the aid of a microscope. The counting process is very tedious and time consuming and, moreover, requires considerable experience.

A method of estimating the extent of algal growth, which renders the use of the microscope unnecessary and which in the opinion of the writer constitutes a much more valuable method, utilizes what the biologist calls a "plankton net." This method is particularly suited to the waterworks man not skilled in laboratory technique. In this method the algae are concentrated in the field. A net made of silk bolting cloth, such as is used in flour mills, is pulled upward through the water and the algae caught in this manner are decanted into a measuring cylinder and their volume noted after sedimentation. Results are reported in parts per million by volume and the specimens of algae, by preserving in formaldehyde, may be kept indefinitely. If it is desired, a microscopic examination of the catch may be made, and the predominating types of algae recorded, but such estimation is not absolutely necessary.

The following description of a plankton net is abstracted from Ward and Whipple's "Fresh Water Biology."

A plankton net consists simply of a conical bag of silk bolting cloth, about 30 inches deep, hung from a metal ring 12 or 14 inches in diameter. The silk

may be purchased from a dealer in flour mill supplies. Two nets may be made from a yard of cloth by cutting the material diagonally. The pieces are then formed into cones and closed by a French seam. The top is finished by sewing on a band of linen cut bias and provided with a heavy cord sewed into its upper margin. The net is attached to the ring by overcast stitches of heavy thread. A stoppered funnel attached to the apex of the cone will facilitate the removal of the catch.

In conclusion, the writer wishes to affirm that a water treatment process without some form of laboratory control is likely to be unsatisfactory and uneconomical; and moreover, the best laboratory control, even where an experienced technician is available, is one wherein the plant operator is trained to make simple control tests in order that he may more fully appreciate the desirability and even the necessity of good operation.

SOCIETY AFFAIRS

NORTH CAROLINA SECTION

The fourth annual meeting of the North Carolina Section was held at Charlotte, N. C., November 12 and 13, 1924. The total registration was 217, which was the greatest number of water works men ever attending a convention in North Carolina.

The first business on the morning of November 12 (President J. C. Michie presiding) was the appointing of tellers to canvas votes for the election of new officers. The minutes of the last meeting were read and approved. The report of the Secretary-Treasurer was read and approved. This report, in abstract, was as follows:

Figures on the growth of the Section

	DATE	NUMBER OF MEMBERS	PER CENT INCREASE
Organization meeting	August, 1921 (Greensboro)	22	
1st annual meeting	December, 1921 (Greensboro)	26	15
2nd annual meeting	November, 1922 (Gastonia)	37	42
3rd annual meeting	November, 1923 (New Bern)	57	54
4th annual meeting	November, 1924 (Charlotte)	59	56

The rates of increase noted from above have exceeded those for any other local Section for the past three years, thus winning for three successive years the Hill Membership Cup. The Cup now becomes the permanent property of the Section, to dispose of as it wishes. For the first time the papers presented at the annual convention of the Section have been printed as a Bulletin of the North Carolina Section. Most of the papers were printed also in the Journal of the Association. The net credit balance in the treasury, after the payment of a few outstanding bills and the expenses of the meeting, was estimated to be well over $25.00.

There was an amendment of the by-laws whereby

An organization of members of the Section particularly interested in filter plant operation may be effected under the title "Filter Operators Conference, North Carolina Section, American Water Works Association." This Con-

ference shall elect each year a Chairman and Secretary to be voted for on the annual ballot of the Section. Officers of the Conference shall be nominated by the Conference in a similar way to officers of the Section. Members of the Conference must be members of the Section.

Mr. G. M. Grantham, Chairman of the State Plumbing Code Committee, reported that this Committee had pursued a course of watchful waiting until the Model Plumbing Code drafted by the Department of Commerce should make its appearance. The Code has recently been issued and, at Mr. Grantham's recommendation, a committee of four was appointed with power to act in this matter in conjunction with the Committee appointed by the State Plumbers Association.

The By-Laws Committee had no report.

Mr. Miller, for the Statistics Committee, reported that a questionnaire would be sent out in order to collect and make available in a tabular form statistics from the various water works systems which would be of practical interest and value to the water works men. The request was made that all water works men, when they receive these questionnaires, would give them careful attention.

Mr. Brockwell, Chairman of the Stream Flow Committee, presented the following resolutions as a report from his Committee:

1. That every water works department in the State ought, for the protection of its consuming public and as a service to the State at large, to make annual appropriation for installation and maintenance of stream gaging stations on streams now used or likely to be used for water supply or waste disposal.

2. The State Geological and Economic Survey should extend materially its investigations of stream flow on the smaller streams likely to be used for municipal water supply or disposal of trade waste.

3. Due to the widespread use of stream flow data for various purposes and by various interests, it is important that all stream flow data and investigations be carried on under the general oversight of a central authority. The State Geological and Economic Survey is the central body which should be charged with this duty. This body has for many years been charged with the collection of stream flow data, and has the close coöperation of the highly trained forces of the United States Geological Survey on this work.

4. For the proper carrying out of the above recommendations on the part of the North Carolina Geological and Economic Survey, the next State Legislature should appropriate $40,000.00 for the stream gaging work by said Survey. In carrying out this stream gaging program the State Geological Survey should consult with the Committee on Stream Flow of the North Carolina Section, American Water Works Association.

5. The State Section, American Water Works Association, should collectively memorialize the legislature to grant the above appropriation, and each

member of the Section should make it his individual duty to impress the necessity for this appropriation upon his local representative and senator and urge them to vote for it.

After some discussion these resolutions were adopted.

The Executive Committee presented the following resolutions regarding the disposition of the Hill Cup:

1. The Cup be suitably inscribed with the fact that the North Carolina Section has permanently acquired its possession by winning it three times in succession.
2. The North Carolina Section returns the Cup to the parent Association to become the permanent property of that Association and to be called the Nicholas Hill Cup.
3. It shall hereafter be awarded annually to that Section having the greatest increase in membership for the preceding year.
4. It shall be inscribed only with the names of those Sections winning the Cup three years in succession.

These resolutions were adopted.

There was a paper by Mr. W. E. Vest on "The Development of the Charlotte Water Works," after which the meeting adjourned until 2:00 p.m.

Following the inspection of the new 10,000,000 gallon filtration plant, designed by W. M. Piatt, the members of the Section and the guests were treated to a barbecue at the plant.

On the afternoon of November 12, the meeting was called to order at 2:00 o'clock, President Michie in the Chair.

The tellers appointed to canvas votes for the election of officers reported the following elections: President, W. E. Vest; Vice-President, E. G. Godfroy; Secretary-Treasurer, Thorndike Saville, H. L. Shaner, gave a paper on "The Impounding Reservoir—Its Troubles and the Remedies." This paper was discussed by Whitlock, Widenhouse, True and Gibson.

M'Kean Maffitt for the Committee on Cross Sections presented a resolution to the effect that the State Board of Health promulgate the necessary regulations to prohibit the possibility of contamination of public water supplies by cross connections, and this resolution included the following suggested rules: (1) Where there is a pump on the auxiliary supply there shall be no physical connection with the city system. (2) Where there is no pump on the auxiliary supply and the tank or tower is filled with the city water it will be permissible for a direct connection. (3) Where there is a pump and

a tank on the auxiliary supply and there is a physical connection between the tank and the pump there can be no physical connection between the tank and the city supply. (4) Where there is an underground reservoir on the auxiliary supply that is filled with water from the city system there shall be no physical connection with the city system unless the underground reservoir is water tight and contamination proof. That is, if there be a possibility of the reservoir from which the auxiliary pumps take water becoming polluted there shall be no physical connection with the city system either from the pump or the reservoir. This resolution was adopted.

Thorndike Saville presented a paper in abstract on "Red Water Troubles in Distribution Systems and Their Control." W. H. Scott of the Duriron Company read a paper on "The Manufacture of High Silicon Irons and Their Application by the Water Works Engineer." C. E. Rhyne gave a paper on "Experience with Chemical Dry Feeders." C. W. Smedburg gave a paper on "Important Problems of Plant Operation." J. W. Kellogg gave a paper on "Interpretations of Water Analysis Reports."

After these papers the meeting adjourned.

There was a dinner tendered to about 150 members and guests at 6:30 at the Charlotte Hotel.

The meeting was again called to order on Thursday morning, November 13, at 9:30, President Michie in the Chair.

The Secretary read a paper on "Relation of Forest Reserve to Conservation of Public Water Supply," Written by W. W. Ashe.[1] This paper was discussed by Mr. Logan and Mr. True.

Mr. Heater read a paper on "Experience in Drilling Wells for Water Supply in North Carolina." This paper was discussed by Miller, Godfroy, Cole and Sydnor.

The Resolution Committee presented a set of resolutions expressing appreciation for the many courtesies extended by the city of Charlotte and by various organizations to further the comfort and profit of the convention. These resolutions were adopted.

It was moved and carried that a committee be appointed to report at the next meeting on the subject of deep well legislation. This committee was appointed.

It was decided that the next annual convention would be held at Asheville.

G. D. Norcom read a paper on the "Relation of Water Supply

[1] This Journal, page 404.

and Sewage Disposal." In connection with this subject Mr. True spoke very highly of the successful manner in which the State Board of Health is handling the question of the pollution of streams by municipalities and communities.

Mr. Grantham gave a discussion on "What Compulsory Connection Does for Water Works Income."

On motion the meeting adjourned.

At 2:00 o'clock Thursday, November 13, the meeting was called to order by Mr. Vest, the President-elect.

Mr. Fields gave a paper on "Does 100 Per Cent Metering of Small Town Systems Pay?" This paper was discussed by Gibson, Maffitt and Grantham.

Mr. Maffitt read a paper on the "Relationship of the Master Plumber to Industrial Development in North Carolina." Mr. Grantham said that the proposed state plumbing code is the most important relationship of the master plumber to the industrial development in this state at present.

The Secretary suggested a resolution of thanks to the press for writing up the proceedings of the convention so thoroughly and placing them in a conspicuous place on the front page. This suggestion was accepted.

Upon motion the meeting adjourned to re-convene in Asheville for the 1925 session.

FIRST CONFERENCE OF FILTER PLANT OPERATORS, NORTH CAROLINA SECTION

A Conference of Filter Plant Operators, held the day preceding the annual meeting of the North Carolina Section, was called to order on Tuesday morning, November 11, 1924, at the Hotel Charlotte, E. G. McConnell of Charlotte presiding.

G. C. Catlett, of the State Board of Health, explained the objects in having a separate conference of filter plant operators, (1) there are many plants that have no filtration problems, (2) superintendents of larger plants have their own operators and are not interested in filtration problems, (3) the time of the general convention being short, there is no time to read the papers on filtration and have the discussions of interest to this particular group. Mr. Catlett explained that the idea was to see whether a separate filter operators meeting proves a good plan, and if the men though it was, to make

it a permanent feature to meet separately at the conventions of the Section.

Mr. McConnell addressed the Conference on "Observations with Hydrogen Ion Concentration in Plant Control." There was a general discussion of plant testing by Norcom, Worth, True and Catlett.

The following questions were discussed:

1. Is the Clark color chart satisfactory or are the tube standards preferable in making hydrogen ion concentration tests: The group voted the charts to be satisfactory, but not preferable.

2. Do the jar tests agree with similar dosages in actual plant operations? The group voted that the jar tests give reasonable indication of actual dosage and are of value in routine operation.

3. Does the Difco dehydrated eosin methylene blue medium give satisfactory results? The group considered the eosin methylene blue medium the best for routine work, especially in small plants.

Mr. Norcom read a paper on "Filter Plant Records Needed under North Carolina Operating Conditions." This was followed by a discussion by True, Catlett, Miller and Gibson.

Mr. Niesley, Secretary of the Association, made a brief talk.

It was voted to have a meeting of this Conference each year in connection with the State Association. A Nominating Committee was appointed to select a Chairman and a Secretary for this Conference.

The meeting adjourned until 2:00 o'clock.

The meeting was again called to order at 2:00 o'clock on November 11.

Mr. Saville, Chairman of the Nominating Committee, gave the following proposed amendment to the by-laws of the Section:

> An organization of members of the Section particularly interested in filter plant operation can be effected under the title "Filter Operators' Conference, North Carolina Section, American Water Works Association." This Conference shall elect each year a Chairman and Secretary, to be voted for at the annual body of the Section. Officers of the Conference shall be nominated by the Conference in the same way as officers of the Section. Members of the Conference must be members of the Section.

Assuming that this amendment would be accepted by the Section the Committee nominated Mr. McConnell for Chairman and Mr. Catlett for Secretary of the Filter Operators' Conference. These nominations were confirmed.

Mr. Gibson gave a paper on "The Use of a Secondary Alkali Treatment to Regulate Corrosive Properties of Water."

There was a discussion as to whether the empiric rule of adding alkali until 8 to 10 parts per million alkalinity is obtained in finished water proves satisfactory. In his discussion, Mr. Smedberg said that in his own experience it was not a case of alkalinity, but one of maintaining lower CO_2 and for that purpose they added soda ash to effluent to maintain a pH of about 7. Mr. Menke of Alabama said that they maintained an alkalinity of 10 to 12 parts and found red water in the main; they brought up the alkalinity to about 17 by the addition of a half grain of lime and the water cleared up.

Mr. Gibson stated that the reduction in capacity of a water main due to tuberculation was necessarily directly proportional to the decrease in diameter. He found that when he reduced the carbon dioxide content below 5 parts per million with lime he might still have red water troubles provided that the hydrogen ion concentration was high. It was necessary to reduce both the carbon dioxide content and the hydrogen ion concentration in order to get a non-corrosive water. Mr. Saville stated that Mr. Gibson's findings were in accordance with recent knowledge about the relation between carbon dioxide in water and the hydrogen ion concentration. So long as the free carbon dioxide is kept down the hydrogen ion concentration will be reduced. The reduction in corrosion which follows reduction in free carbon dioxide content and hydrogen ion concentration is not due primarily to a lesser number of hydrogen ions in the water, but is due to the fact that low hydrogen ion concentration signifies generally that the free carbon dioxide is either absent or combined with carbonates to form soluble bicarbonates. If the hydrogen ion concentration is reduced artificially by adding alkali to the water the reduction really comes about by removing free carbon dioxide and hence allowing carbonates to precipitate. The precipitated carbonates form a thin film on the pipe and prevent corrosion. The fact that reduced corrosion gives reduction in hydrogen ion concentration (or increase in pH) is merely an indication that any carbonates present have precipitated. Reduced hydrogen ion concentration is, therefore, chiefly an index and only indirectly a cause of reduced corrosion.

There was a discussion as to whether the present commercial machines for dry feeding chemicals are a complete success, and, if so, is dry feed superior to solution feed, and the question came up as

to whether alum should be used before the lime or lime before alum or both at the same time. Mr. Norcom said he was using both at the same time. Mr. Menke suggested that the question as to which should be added first is a matter of individual waters.

Mr. J. W. Kellogg, of the State Laboratory of Hygiene, addressed the Conference on "The Presence of Free Alum in Filtered Waters and the Testing for Same." He told of tests that had been made at the State Laboratory on water containing soluble alum in which they had found a certain relationship between pH and the amount of soluble alum. Mr. Gibson said that he found free aluminum in his water all the time and he had found the haematoxylin test useless. Mr. Norcom said he had free alum in his water all the time and believed that it occurs in all plants using alum for coagulation, but he hoped to get down this free alum by the use of chemicals applied directly to clear water. Mr. Kellogg gave an example of one plant, from which samples had been sent to the State Laboratory, in which the amount of free alum was almost negligible.

Mr. Smedberg read a paper on "The Importance of Keeping Controllers and Gauges in Proper Shape and the Value of Such Plant Efficiency." Mr. True told of his satisfactory experience in the use of the Simplex Controller. Mr. Gibson spoke of the importance of maintenance in connection with plant apparatus.

INDIANA SECTION

The water works men of Indiana met for the first time as a section of the American Water Works Association. Many of the members of the former association applied for membership in the American and it appears that a majority will come in.

The meeting was called to order by the President, W. L. Younce, at 10:00 a.m., January 22 in the Palm room of the Claypool Hotel, Indianapolis. In his address the President called upon the members to exert themselves toward making the organization a more effective one as a section of the American Water Works Association than it ever had been as a state gathering.

The report of the Secretary-Treasurer showed the association to be solvent and able to carry on the necessary business of the coming year.

The President appointed J. W. Toyne, South Bend, W. H. Durbin, Terre Haute and W. C. Mabee, Indianapolis as members of the

nominating committee; and H. E. Jordan, Indianapolis, L. I. Birdsall, Chicago and L. A. Geupel, Indianapolis, as a committee to draft a new constitution for the government of the body as a section of the American Water Works Association.

J. J. O'Brien, Fire Chief of Indianapolis, spoke on "Keeping up the Teamwork." Chief O'Brien has been instrumental in developing in other cities, the same friendly, helpful spirit that exists between the Fire Department and the Water Company in Indianapolis.

Dow R. Gwinn, "Dean" of Indiana Water men, read a paper on utility operation in which he emphasized the value of courtesy and consideration on the part of utility employees in their contact with the public.

Handling accounts of slow paying consumers was discussed as a round table in which "penalty" and "discounts" were weighed. E. M. Sherborne, Knightstown, reported that they used no collectors and lost in 1923 only 75 cents which was owed by a man at the time of his death. In 1924 they lost more, $2.35, but expected to obtain at least part of it eventually, W. F. Peter, Seymour, lost one month's bill from a man who left town overnight. While many water companies and departments may be having their collection troubles, some, at least, can devote their entire attention to operation without financial worries interfering.

The luncheon, afternoon session and dinner were joint with the Indiana Public Utility Association, about 250 being present in the afternoon and 500 in the evening. The Hon. F. H. Van Orman, Lt. Governor, of Indiana, addressed the meeting at the Luncheon, and Maj. Gen. G. H. Harris of Chicago, the meeting at the dinner.

The program of the second day, January 23, opened at 8:30 a.m with an inspection trip of the meter repair department of the Indianapolis Water Company, where an especially efficient organization has been built up.

At 10:00 a.m. the meeting reconvened in the Palm Room at the Claypool Hotel, hearing, first, the report of the constitution committee which was accepted and the committee instructed to submit it to the national Association for approval.

Richard Lieber, Director of the Indiana Department of Conservation, reported the activities of the department along the line of stream flow measurements and indicated that about 180,000 h.p. could be developed without storage. About 20 gauging stations have been established.

F. S. McClintock, Chief Engineer of the Dravo-Doyle Company, at Pittsburg, presented figures showing the relation between installation and operation cost of steam and electric pumps. He detailed the equipment assembly to provide an efficient unit of low capacity as the demand grows. The discussion which followed the paper, brought out many instances of material economies as a result of changing from steam to electrically driven pumps. Emphasis was placed upon the necessity for studying the conditions and designing pumps to meet the particular service required.

F. C. Jordan, President of the American Water Works Association outlined "The Aims of the American Water Works Association." The development of a close relationship between the members through the executive committee and between the sections and national body is assured. The spring meeting in Louisville will offer an opportunity for the new Indiana members to establish contact with the parent body.

Dean A. A. Potter, of the Purdue University School of Engineering, offered the water works men every assistance at his disposal for the study of problems looking to improvement in methods. This school has been particularly active in Indiana industrial circles and has under way extensive investigations.

A round table on "Where does the water go between midnight and 6:00 a.m." brought out a number of interesting tabulations and observations.

"Measurement of Pipe Flow by the Coordinate Method"[2] was presented by F. W. Greve of Purdue University.

J. W. Moore of Indianapolis detailed the basic conditions governing the placing, conditioning and equipment of wells.

New water works construction in Indiana was reported by W. H. Durbin at Terre Haute, where new filters are being put into service. W. L. Younce at New Castle has practically a new pumping station, the old units having been renewed. Charles Brossman reports a new ground supply being developed at Boonville. He is also completing a roller dam at Ft. Wayne designed to provide a lake for recreation in both summer and winter, yet leaving a completely unobstructed channel during flood periods. In connection therewith there is a Hydroelectric Power Station operating automatically which is tied in with the municipal light plant.

Approximately 175 men attended the meeting.

[2] Journal, March, 1925, page 306.

The following officers were elected: President, J. O. Endris; Vice-President, Wm. Luscombe; Secretary-Treasurer, C. K. Calvert; Assistant Secretary-Treasurer, B. H. Jeup.

NEW YORK SECTION

The relation of plumbing to the water works superintendent was the subject discussed at the January meeting of the New York Section following a luncheon on Thursday, January 22, at the Hotel Pennsylvania. The occasion was a joint meeting between the Section and the Sanitary Engineering Section of the American Society of Civil Engineers. The principal speaker was Albert L. Webster, consulting engineer, who was introduced by President D. W. French, of the Section.

Mr. Webster spoke on the report[3] of the committee on plumbing of the building code committee, appointed by United States Secretary of Commerce Herbert Hoover. The speaker prefaced his paper by a short eulogy of the work accomplished by the late Prof. George C. Whipple, of Harvard University, who up to the time of his death was chairman of the committee. Mr. Webster said that Prof. Whipple was to have spoken at this meeting and that he took his place with the greatest reluctance. He spoke of the great importance of the plumbing of buildings in respect to both water conservation and health.

The first speaker to discuss the paper was A. E. Hansen, consulting engineer, who also paid a feeling tribute to the late Prof. Whipple. The chairman, he said, had to deal with master plumbers, sanitary engineers, architects and even the representatives of labor and Prof. Whipple in this capacity, had handled the situation wonderfully and had brought these elements together as no one else could have done. The speaker said that, as a member of the committee, he felt that he was not qualified to discuss it, and suggested that William W. Brush tell the meeting how New York handled the situation.

Mr. Brush spoke at length on the rules and regulations of New York City governing plumbing work in buildings and cited some of the problems which had been met.

The sanitary engineers at this point were compelled to retire, as there was a meeting of their own section in another part of the hotel. The chairman declared a recess, at the conclusion of which the New York Section reconvened and a resolution was passed to empower the

[3] This Journal, page 418.

board of governors to prepare a set of resolutions on the death of John M. Diven, Secretary Emeritus, of the Association, and to have the same properly engrossed and forwarded to the family of the deceased. The meeting then adjourned.

HONOR ROLL

January 31, 1925

Applications Secured by Members from April 1, 1924 to January 31, 1925

	Number
Frank C. Jordan	15
Samuel B. Morris	14
G. F. Catlett	5
Wellington Donaldson	5
Thorndike Saville	5
H. G. Baity	
Jack J. Hinman, Jr.	4
H. E. Miller	4
John M. Diven	3
Edward A. Geehan	3
James C. Harding	3
Emil Nuibling	3
Abel Wolman	3

Each of the following have secured two new members:

C. M. Baker
James Bedell
E. B. Besselievre
L. I. Birdsall
George W. Booth
G. A. Crooke
W. W. DeBerard
W. H. Dittoe
H. M. Ely
George W. Fuller
Burt B. Hodgman
Charles G. Hyde
Edgar B. Kay
Fred J. Klaus
Morris Knowles
R. E. McDonnell
John F. Reagan, Jr.
L. A. Smith

Each of the following have secured one new member:

J. Walter Ackerman
George C. Andrews
A. G. Barnett
R. J. Bauereisen
F. E. Beck
Harwood Beebe
Charles H. Bliven
C. D. Brown

O. E. Bulkeley	R. W. Martindale
A. M. Buswell	Andrew B. Mauzy
James M. Caird	J. R. McClintock
J. N. Chester	Isador W. Mendelsohn
Michael F. Collins	Richard Messer
H. F. Cox	John T. Metcalf
W. S. Cramer	Leonard Metcalf
C. M. Daily	Arthur P. Miller
C. S. Denman	E. E. Minor
P. Diederich	Charles H. Morris
R. L. Dobbin	Reeves J. Newsom
F. C. Dugan	Malcolm Pirnie
Almon L. Fales	Arthur H. Pratt
O. O. Farmer	Andrew J. Provost
Harry F. Ferguson	George W. Putnam
G. J. Fink	L. A. Quayle
W. S. Finlay, Jr.	Joseph Race
H. A. Gallagher	George R. Russell
W. R. Gelston	D. A. Reed
F. Godfroy	Arthur L. Sherman
John M. Goodell	V. Bernard Siems
E. D. Hardy	Harold C. Stevens
W. H. Henby	C. J. Sullivan
Charles R. Henderson	C. V. Swearingen
Mentor Hetzer	E. O. Sweet
Nicholas S. Hill, Jr.	Robert J. Thomas
F. C. Hopkins	E. S. Tisdale
Alexander Houston	Albert Tolson
N. J. Howard	D. M. Tyler
S. W. Jacobs	L. Van Gilder
Harry E. Jordan	C. A. Van Keuren
James H. Judge	L. M. Wachter
John W. Judson	F. H. Waring
J. W. Kellogg	Earle L. Waterman
Frank C. Kimball	Vernon West
Carl F. Klapp	Melville C. Whipple
Charles R. Knowles	L. G. Whitley
R. W. Lawton	C. M. Whitlock
W. D. Leonard	Ezra B. Whitman
J. C. Lightfoot, Jr.	H. A. Whittaker
W. B. Livezey	Ernest C. Willard
Chester H. Loveland	John Wilson
McKean Maffitt	Frank Winsor
George A. Main	

Total secured by members	202
Secretary's Office	80
New members from April 1, 1924, to January 31, 1925	282

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Determination and Hygienic Importance of the Number of Bacillus Coli in the Ozone-Treated Water in Hermannstadt. Wilhelm Stern. Centr. Bakt. Parasitenk., II Abt. **54**: 209–14, 1921; Absts. Bact., **5**: 399. From Chem. Abst., **16**: 4291, Dec. 10, 1922. Following method is suggested: To 100 cc. of medium containing 5 per cent peptone, 5 per cent lactose, and 2.5 per cent sodium chloride, add 0.5 cc. of 10 per cent alcoholic solution of fuschin and 2 cc. of freshly prepared 10 per cent sodium sulphite and place 2 cc. of mixture in each of a series of 14 tubes. 10 cc. of water sample are added to tubes I–II; 5 cc. of water and 5 cc. sterile salt solution to III–IV; 2.5 cc. water and 7.5 cc. sterile salt solution to VII–VIII; 1 cc. water and 9 cc. salt solution to IX–XII; and 0.5 cc. water and 9.5 cc. salt solution to XIII–XIV. When water is poor in B. coli 25, 50, 100 and 500 cc. portions of water with necessary amount of medium are placed in large flasks, and when very rich in B. coli the sample is diluted with sterile salt solution and amounts of 0.1, 0.5 and 1 cc. are tested. Presence of B. coli is indicated by red color when incubated at 37°. A "coli-titer" is then determined arithmetically for 100 cc. of water. While number of bacteria may give no indication of contamination, the "coli-titer" may indicate heavy pollution.—*R. E. Thompson.*

Waste Water. J. Rutten. Het Gas **42**: 90–4, 1922. From Chem. Abst., **16**: 4292, Dec. 10, 1922. Apparatus described for filtering large quantities of waste water containing both floating impurities such as oils and fats, and heavy particles like coal dust. Waste is settled in concrete tank, one wall of which is the filter. Low solid cross wall and another cross wall touching surface of water from above, keep solid and floating impurities respectively from filter, thus preventing clogging. The filter consists of several layers of galvanized iron gauze and tinned brass gauze. It can be readily cleaned.—*R. E. Thompson.*

Action of Chlorinated Water on Galvanized Iron Tanks. N. V. Lothian and A. R. Ward. J. Roy. Army Med. Corps, **39**: 163–70, 1922. From Chem. Abst., **16**: 4290, Dec. 10, 1922. Flavor of chlorinated water, frequently complained of during war, is probably due to containing vehicle, particularly when of common galvanized iron type. While raw water, acting on new zinc-lined tanks, dissolves 4 p.p.m. of zinc in 18 hours, chlorinated water dissolves 20 parts in 24 hours. After 3 weeks use, however, only 2 p.p.m. is dissolved,

owing probably to formation of protective layer of zinc oxide. As long as free chlorine can be detected, amount of zinc is not appreciable; but with disappearance of free chlorine, zinc and alkalinity increase. Zinc remains in solution below concentration of 6 p.p.m.; turbidity appears between 6 and 10 p.p.m.; and at or above 10 p.p.m. zinc is precipitated as dirty-grey flocculent deposit of zinc hydroxide with traces of carbonate (corresponding to pH 7.8). Zinc solvency can be corrected by addition of large amounts of chalk to aid formation of coating of zinc carbonate, or by use of bituminous "paint." Latter delays disappearance of chlorine, ensuring longer sterility. Water from tanks treated in latter manner has strong sooty taste of tar oils, which disappears after 2 weeks use. Toxicity of zinc in water is doubtful.—*R. E. Thompson.*

The Detection of Fecal Water Contamination by Means of Indole Test. ALFONS GERSBACH. Centr. Bakt. Parasitenk., I Abt., **88**: 145–50, 1922. From Chem. Abst., **16**: 4292, Dec. 10, 1922. To same quantity of broth containing tryptophan decreasing amounts of water to be tested are added and after incubating 1 or 2 days at 37° mixtures are tested for indole with the Ehrlich-Böhme reagent as modified by Frieber.—*R. E. Thompson.*

Using Lime for Treating Colloidal Color in Surface Waters. R. S. BUZZELL. Rock Products, **25**: 18, 16–17, 1922. From Chem. Abst., **16**: 4290, Dec. 10, 1922. Sufficient lime is added at Flint, Mich., to break up the colloidal color; subsequent addition of 0.5–1.0 grain per gal. of alum effects excellent clarification. Chlorine required for sterilization has been reduced from 0.7–0.85 to 0.3 p.p.m.—*R. E. Thompson.*

The Influence of Mechanical Methods of Mixing on the Chlorination of Drinking Water. A. ORTICONX and NEPVEUX. Rev. hyg., **41**: 213–23, 1919; Abst. Bact., **5**: 341, 1922. From Chem. Abst., **16**: 4290, Dec. 10, 1922. Improved mixing and distributing conditions make possible decrease in chlorine dosage and in time necessary for purification. Authors advise utilization of aspirating action obtained by using with motor pump 2 Y-branches of different caliber, larger one for water and smaller for chlorine delivery. Establishment of "index of purification," instead of merely a chemical index of chlorine used, is suggested for controlling treatment.—*R. E. Thompson.*

Changes in the Reaction of Fresh Water under the Influence of Aquatic Plants. LOUIS LAPICQUE and THÉRÈSE KERGOMARD. Compt. rend. soc. biol., **87**: 512–5, 1922. From Chem. Abst., **16**: 4253, Dec. 10, 1922. Experiments with Spirogyra, Potamogeton and Elodea showed that presence of 1 gram of fresh plant per 50–100 cc. affected reaction of water. In dark, alkalinity diminished; while in light, pH increased from 7.2–7.6 to 9–10. Mechanism of this change in reaction is obvious, being dependent on liberation and assimilation of carbon dioxide.—*R. E. Thompson.*

Control of Water Supply in Chemical Industry. ALBERT NEUBURGER. Chem.-Ztg., **46**: 803, 1922. From Chem. Abst., **16**: 4290, Dec. 10, 1922. Plea

for accurate metering of water to boilers, solution tanks, etc., in chemical plants, in order to economize fuel, time, and labor. For such purposes meters should have an error not exceeding 1 per cent.—*R. E. Thompson.*

Soft Waters of Central New York. Nicholas Knight and J. B. Shunmaker. Proc. Ia. Acad. Sci., **27**: 165–6, 1920. From Chem. Abst., **16**: 4290, Dec. 10, 1922. Comparative analyses given of two samples of water from wells 43 and 12 ft. deep respectively.—*R. E. Thompson.*

The Relative Effects of Certain Triphenylmethane Dyes upon the Growth of Bacilli of the Colon Group in Lactose Broth and Lactose Bile. C. -E. A. Winslow and A. F. Dolloff. J. Infectious Dis. **31**: 302–4, 1922. From Chem. Abst., **16**: 4242, Dec. 10, 1922. In both lactose broth and bile (or sodium choleate) rosolic acid is inhibitive in concentration of 1 in 1000 for all 5 organisms studied. Gentian violet is 5 to 50 times as toxic as rosolic acid in broth, individual organisms showing marked variations in susceptibility, while in bile medium toxicity is same as rosolic acid. Brilliant green inhibits organisms studied in concentrations of 1:100,000 to 1:1,000,000 in broth, B. aërogenes being more resistant than B. coli; but in presence of bile salt this toxicity disappears, B. aërogenes and B. pneumoniae growing even in concentration of 1: 500.—*R. E. Thompson.*

The Acid Production of Bacillus Welchii. Ivan C. Hall and Samuel B. Randall. J. Infectious Dis., **31**: 326–33, 1922. From Chem. Abst., **16**: 4243, Dec. 10, 1922. Cultures of B. welchii in peptone meat mash medium containing excess glucose, levulose, galactose, lactose, or saccharose show distinct peak, followed by depression, in H-ion concentration and titratable acidity, precluding possibility of change in direction of such curves serving as proof of freedom from sugar. Theory of escape of volatile acids is rejected and hypothesis suggested that portion of acid first formed is subsequently destroyed. Recessions in acidity, when excess fermentable sugar is present, are insufficient to confuse qualitative fermentation tests. Limiting pH values for above sugars are approximately equal; also titratable acidities for all but lactose; B. welchii never produces quite as much acid from lactose owing possibly to different dissociation constants in end products.—*R. E. Thompson.*

Volumetric Determination of the Sulphate Ion in Potable Water. J. Kuhlmann and J. Grossfeld. Z. Nahr. Genussm., **43**: 377–80, 1922. From Chem. Abst., **16**: 3993, Nov. 20, 1922. To 100 cc. of sample add 25 cc. $BaCl_2$ solution (12 g. crystals to 1 l.) and, 10 minutes later, 25 cc. K_2CrO_4 solution (18 g. crystals to 1 l.). Allow to stand 10 minutes and filter. Add to 100 cc. of clear filtrate 10 cc. of 10 per cent KI and 5 cc. of 25 per cent HCl, and titrate with 0.1 N $Na_2S_2O_3$. Deduct blank carried out on 100 cc. distilled water. Each cc. of thiosulphate is equivalent to 2.67 mg. SO_3, corresponding to 4 mg. in 100 cc. of sample, allowing for 50 cc. of solution not used in titration. Results are accurate.—*R. E. Thompson.*

Nitrogen and Other Compounds in Rain and Snow. Jacob E. Trieschman and Nicholas Knight. Proc. Iowa Acad. Sci., **27**: 159–64, 1920. From

Chem. Abst., **16**: 3993, Nov. 20, 1922. Chlorine content of rain and snow at Mt. Vernon, Iowa, during period from Oct. 1, 1918 to June 5, 1919, varied from 6.1 to 25.7, and averaged 11.12 p.p.m. Average total nitrogen for each precipitation was 1.046 p.p.m.; free ammonia 0.407; albuminoid ammonia 0.366; nitrates 0.255; and nitrites 0.018. Of total nitrogen contained during the period, 38.85 per cent was present as free ammonia, 34.99 per cent as albuminoid ammonia, 24.42 per cent as nitrates and 1.74 per cent as nitrites. Of 46 samples analyzed, only 15 produced sufficient sulphate for determination and only 11 others showed slight trace. Average for the period was 0.03 p.p.m. Five samples contained trace of phosphate, while only 4 contained sufficient for determination, average being 0.002 p.p.m.—*R. E. Thompson.*

Accelerated Weathering of Paints on Wood and Metal Surfaces. H. A. Nelson. Am. Soc. Testing Materials, June, 1922; preprint, 15 pp. Chem. Abst., **16**: 4071–2. Nov. 20, 1922. Of commercial paints for protecting iron, both the combination of 83 per centiron oxide and 15 per cent zinc oxide, and 100 per cent red lead showed outstanding merit in maintaining gloss and inhibiting rust formation compared both with iron oxide paints reduced with various fillers, and reduced zinc oxide—sublimed lead paint.—*R. E. Thompson.*

Various Aspects of the Cardiff Waterworks Undertaking. Neil J. Peters, H. W. B. Cotterill, B. Santo Crimp. Water & Water Eng., **26**: 5, January 21, 1924. Description of 12 million gal. (Imp) Wenallt storage reservoir; of 1,260 million gal. Llwyn-on impounding reservoir; and of No. 2 pipe line, between corporation watershed in Breconshire and lower terminal storage reservoirs at Llanishen. No. 1 pipe line is of cast-iron, 48 miles long, and action of soft moorland water has reduced carrying capacity from about 11½ to 7 m.g.d. No. 2 pipe line is 29.21 miles long, half 27-inch, and half 29-inch diam., with carrying capacity of 15 m.g.d. As alternatives for cast-iron, in constructing latter, "Bonna" reinforced concrete, cast-iron concrete lined, and steel concrete lined were considered. Concrete pipe was ruled out as too expensive; difference in cost between cast-iron pipe in 12-foot lengths and steel tube in 24-foot lengths, concrete lined in both cases, was practically nil. Latter was finally adopted with the great advantage of uniform thickness throughout, securing complete standardisation without extra cost. Concrete lining, ½-inch thick, will be centrifugally applied. Extreme tenacity of centrifugally applied concrete was demonstrated by picking up and dropping upon rails of pipe crane a properly set pipe: no damage to lining was observed. Cutting of concrete lined pipe by oxy-acetylene flame was found impracticable; but joints could be welded with good results. Welded pipe, still hot, sustained pressure of 1300 feet head without damage to lining. Owing to trouble with drawn lead joints over colliery areas on No. 1 pipe line, engineer decided to weld joints on No. 2 line. In this section ground is slowly subsiding throughout a length of about 8000 feet. Further subsidence of 5 feet should not greatly affect 8000-foot length of uniform pipe. Automatic sluice valve will be set at point to relieve by 200 feet the head coming on lower length of line. Valve is type known as Edwards patent, is practical application of Venturi principle to ordinary sluice valve. Rise in Venturi head at contracted area,

point of valve insertion, is utilised to set off tumbler weight admitting full pressure of main on to piston, on lower end of rod of which is sluice valve. In this case problem was not only to set valve off for increased flow, for which original valve was designed, but also to operate it if velocity at throat fell below a pre-determined amount, which would mean that sluice vale on lower length of line was being closed, and static head consequently increasing.—*Geo. C. Bunker.*

Welsh Water. George R. Collinson. Water & Water Eng., **26**: 13, January 21, 1924. Discussion as to allocation of surplus water from available catchment areas in Wales to English communities after local needs met. Liverpool, Birmingham, and Birkenhead have run their aqueducts into Welsh mountains and proposals have been made more than once to supply London with Welsh water. Country's water resources are so small as compared with probable future requirements, that large and wealthy authorities, like Liverpool and Birmingham, should not be allowed to select only best and most elevated reservoir sites. Each river or stream should be developed as a whole in respect of its water resources, even though it may be necessary in connection with supplies drawn from lower levels to employ booster pumping for development of necessary pressure. It is bound to come to this sooner or later, and it will be sounder policy and more economical in long run, to face facts at once and act upon them. Short discussion follows on page 21 of same issue.—*Geo. C. Bunker.*

Relation of Compensation Water to Stream Flow. F. W. Macaulay. Water & Water Eng., **26**: 15, January, 21, 1924. Proposed to recommend that Parliamentary Committees shall in future adopt actually measured stream flows as basis upon which to assess quantity of compensation water to be given to streams impounded for domestic supply purposes, instead of, as at present, estimated rainfall upon gathering ground. Short discussion follows on page 19 of same issue.—*Geo. C. Bunker.*

Water Supply Legislation. Percy Griffith. Water & Water Eng., **25**: 449, December 20, 1923. Outlines of scheme for discussion by British Waterworks Association and Institute of Water Engineers with view to legislation. Definitions are proposed for the following terms: waterworks; domestic requirements, or purposes; agricultural, farming, and gardening requirements, or purposes; source; water authority; water-supply authority; pure and wholesome water. Definition for last-mentioned is water which, on being tested by chemical and bacteriological examination, and having regard to the conditions of the source and means of distribution, constituting the waterworks as above defined shall, in the opinion of a competent analyst, medical officer, or other expert recognized by the Ministry of Health, be suitable and safe for domestic use. Discussion follows **26**: 25, January 21, 1924.—*Geo. C. Bunker.*

The Revision of Legislation in Regard to Water Supply. A. R. Atkey. Water & Water Eng., **25**: 460, December 20, 1923. Necessity of urgent reforms

in laws dealing with "compensation water" and "underground water." Discussion follows on page 470.—*Geo. C. Bunker.*

The Institution of Water Engineers, 28th Annual General Meeting, December 11–12, 1923. Water & Water Eng., 26: 30, January 21, 1924. Discussion of above paper. W. T. Burgess discussed methods and difficulties experienced in taking samples from the deep borehole. Apparatus designed for taking small samples of water from deep wells in vacuum tubes, ends of which are broken off at desired depth by release of spring through jerking of wire holding the apparatus, did not work satisfactorily below 450 feet. 1000 feet of No. 20 copper wire in water weighs very nearly 3 lbs, and one cannot tell whether machine is resting on projections, etc., because its weight is small relatively to weight of wire. Apparatus was therefore modified so that weight dropped down the wire forced a plunger to break sealed end of vacuum tube. By this means samples of water were collected from depths to 1000 feet. It was found that weight falling in water did not travel at increasing speed, but, after first few feet, uniform rate. One weight that was used travelled at 12.5 feet per second with such regularity that number of seconds of fall, multiplied by speed per second, measured with certainty the depth reached. Tubes holding 50 cc. were used and ends sealed off before all air exhausted. At depth of 1050 feet, water pressure was more than 31 atmospheres, or 465 lbs. per square inch, so that exhaustion was not really necessary. Tubes were absolutely full when drawn up and not one failed. Water from well is practically destitute of air. Chlorine content is given as 740 p.p.m. About 1,000,000 Imp. gallons per day of this water mixes, 1½ miles from station, with 2,000,000 gallons per day of water with average chlorine content of 16 p.p.m.; 7½ miles further on this water mixes with 4–6,000,000 gallons per day of water with average chlorine content of about 2 p.p.m. Although population of 100,000 people have thus had chlorine content of their drinking water raised from accustomed figure of 16 p.p.m. to from 150 to 200 p.p.m., no complaints have been made. Author of paper admitted in discussion that he did not detect saline flavour of water from borehole. [It is unfortunate that mineral analysis of water was not included.—Abstr.] Only 2 boreholes would be put down at Somerford as compared with 4 which would have been required had reciprocating engines of marine type been selected; change to Diesel driven centrifugal pumps considerably reduced ultimate cost. Turbine pump, properly encased to ensure protection against sand, appears to be coming pump for boreholes and wells. Vertical spindle borehole pump could lift water from depth of 300 or 400 feet: 2 or 3 pumps can be fixed on same shaft, driven by same motor; drive can also be by steam or gas engine.—*Geo. C. Bunker.*

A Comparison between British and American Waterworks Practice. George Mitchell. Water & Water Eng., 25: 462, December 20, 1923. (A stands for North America, or American; B for Britain, or British, according to context.) Main differences are listed as follows: (1) Public opinion is not in general so strong in A as in B. For example, (a) although New York has carried out greatest water supply scheme of all time, it apparently cannot afford to filter its Croton supply, although it has spent scores of thousands of pounds in

designing filters for this purpose. (b) extraordinary case of Chicago, drawing water from polluted lake and delivering it after chlorination direct to consumers without intervention of reservoirs. (2) High consumption of water per head in A. (3) Enormous extent to which chlorination employed in A. (4) Metering of domestic consumption in A. (5) Smallness of compensation water problem in A. (6) High rates of filtration generally used in A slow sand plants. (7) Use of pressure tunnels in hard rock in A. (8) Employment of deep elevated tanks of concrete in A. (9) Dominating point in designing many distribution systems in A is to give good fire service. (10) Special fire protection systems in A cities. (11) Standard specifications for sluice valves, hydrants, and meters are issued in A. (12) Standard of execution of work is in general not quite so good in A as in B. (13) In matter of stream gauging, B is far behind systematic gaugings of streams undertaken by U. S. Geological Survey. (14) Considerable number of A supplies are drawn from sources which would not be looked at in B; A rivers containing large proportions of trade wastes are used; direct abstraction from lower reaches of rivers, with little storage provided, is much more common in A than in B. (15) Purchase of watersheds in B is very common, but in A, very unusual. (16) Stripping of soil from reservoir sites is very uncommon in B except in case of extensive peat deposits. Most remarkable feature of A purification works has been great extent to which chlorination adopted, often as practically sole means of purification. In B there is often unreasonable objection to doctoring water supplies, but these sentimental objections are gradually disappearing. In B mechanical filters of steel cylinder type are those chiefly used although reinforced concrete has lately come into use. Ransome filter, as installed at Toronto, is very little used in B. Slow sand filtration is becoming less common for new plants in A and it appears probable that there will be same tendency in B. Standard rate for B filters is 2.18 m.g. a.d.; but in A this rate is often doubled and still higher rates employed in some cases. In recent large works in A, pressure concrete aqueducts in solid rock have been employed, which are practically unknown in B. For ordinary pressure aqueducts cast-iron pipes have been largely used in both A and B. Automatic shut off valves do not seem to be used in A pipe lines. A steel pipes are practically all riveted pipes riveted continuously into one piece with no special allowance for temperature effects. B steel pipes are practically all lapwelded pipes for larger sizes. There does not appear to be any record case of large pipe in B giving trouble from corrosion. There is now considerable experience of large pipes with 30 years service, and they appear fit for a long period still. Apart from displacement, it is impossible to have serious breakdown in steel pipe line. Reinforced concrete pipes have been largely used in A for low pressures, but in B, Bonna pipe alone of this type has been employed to any extent, although monolithic pipe lines of large diameter are now being tried. In B wood stave pipe is unknown except for temporary purposes. A very large proportion of B service pipes are of lead. Waste detecting meters are largely used in B; meters used for trade supplies in A are generally of cheaper construction than those used in B. Sluice valves used in B are all of solid plug type. Short discussion appears in 26: 23, January 21, 1924.—*Geo. C. Bunker.*

The Telechron Electric Position Transmitter. Water & Water Eng., 25: 473, December 20, 1923. Description of a distant reading water level indicator. Illus.—*Geo. C. Bunker.*

The Engineer and the Public Health. F. A. Dallyn. Can. Eng., 47: 24, December, 1924. Public Health activities outlined. Great Lakes as source of water supply and introduction of water purification in this area discussed. Chlorination of water, and reduction of typhoid fever death rate illustrated by tables. In 13 year period 1910–1922, typhoid death rate per 100,000 of population was reduced in U. S. from 23.5 to 7.5 and in Ontario from 31.5 to 6.0. In Great Lakes cities reductions more pronounced. Toronto 46 to 2.6, Buffalo 20 to 4.2 Erie 39 to 2.7, Cleveland 14 to 1.9, Milwaukee 46 to 1.0 Port Arthur 178 to 0, Duluth 73 to 3.8. Emphasis is laid upon present need of international authority for prevention of pollution of boundary waters. Reference also made to increasing problem of taste prevention in treated waters.—*N. J. Howard.*

Lambton, Ont. Water Works System. R. O. Wynne-Roberts. Can. Eng., 47: 24, December, 1924. Illustrated description of new steel standpipe having capacity of 400,000 imp. gallons. Tank is 100 feet high, 30 feet inside diameter, and is designed for unit stress of 12,000 lbs. per square inch on the net section in tension. Riveted steel plates encased with red bricks were used. Steel structure cost $26,270, brick casing $5,870.—*N. J. Howard.*

A Century of Water Filtration. Can. Eng., 47: 24, December, 1924. Brief description of water purification effected in past 100 years.—*N. J. Howard.*

New Reservoir at Montreal, Que. Abstract of paper by J. F. Brett as presented at Engineering Inst. of Canada. Montreal Branch. New reservoir at Verdun has capacity of 20 mil. imp. gallons costing $625,000, purpose being to hold sufficient filtered water to take care of heavy fluctuations in pumpage. Emergency connection with aqueduct is also provided. Reservoir is 525 × 512 feet, under operating conditions will contain 12½ feet of water, and covers 5 acres. Approximate cost per million gallons $26,000.—*N. J. Howard.*

Shrub Grows in Water Pipe. J. Duncan. Can. Eng., 48: 2, January, 1925. In water pipe at Hollyburn, B. C., a vegetable growth in form of shrub was found, classified as Gaultheria Shallow. It belongs to winter-green family and is comparatively rare excepting in pine woods of Northern California and British Columbia. Shrub grows 1 to 3 feet high and has sticky hairy stems. Leaves are glossy and ovate in form and waxy pink flower with sweetish smell grows on plant.—*Norman J. Howard.*

Pacific Drainage, British Columbia and Yukon Territory. Water Resources Paper 43: Dominion Water Power Branch, Dept. of the Interior, Ottawa, Can., 1924. Eleventh report presenting data of surface water supply in said districts for climatic year ending September 30, 1923.—*M. J. McCrady.*

Annual Report, 1922–23, Dominion Water Power Branch, Dept. of Interior, Ottawa, Canada. Report of activities and Field Reports. Present recorded water power resources of Dominion permit turbine installation of 41,700,000 HP. Total installed to date only 3,000,000 HP or 7 per cent of recorded resources.—*M. H. McCrady.*

Arctic and Hudson Bay Drainage (and Mississippi drainage in Canada) in Alberta, Saskatchewan, Manitoba and Western Ontario. Water Resources Paper, 40: 1924, Dominion Water Power Branch, Dept. of Interior, Ottawa. Hydrometric investigations during climatic year 1921–22.—*M. H. McCrady.*

St. Lawrence and Southern Hudson Bay Drainage, Ontario. Water Resources Paper 42: 1924, Dominion Water Power Branch, Dept. of Interior, Ottawa. Hydrometric investigations during climatic year 1921–22.—*M. H. McCrady.*

The New Forestry Act. American Forests, 30: 367, 392, July, 1924. Discussion of McNary Clarke Forestry Bill. Section 6 is enlargement of Weeks Act authorizing Government to purchase lands on watersheds of navigable streams for timber production as well as for stream flow protection. Annual appropriation of $2,500,000 for fire protection authorized. Appropriation under Weeks Act increased to $800,000.—*G. R. Taylor.*

The Forestry Act. American Forests, 30: 367, 431, July, 1924. Complete text of McNary Clark Act.—*G. R. Taylor.*

The Water Woods of York. J. S. Illick. American Forests, 30: 365, 264–66, May, 1924. The York Water Co., York, Penna., had planted 506,000 trees, beginning 1913, on its watershed. 57 per cent are red pine, 30 per cent white pine, the rest European Larch, Norway Spruce, & Douglas Fir. This has been completely successful in stopping both erosion and silting up of reservoir.—*G. R. Taylor.*

The Grazing of Cattle and Horses in Pine Plantations. Paul Stickel and Ralph C. Hawley. Journal of Forestry, 22: 8, 846–860, December, 1924. Study of effects of grazing on 1900 acres of plantations of New Haven Water Co., Conn. Fire hazard reduced through reduction of ground cover: grazing tends to keep down hard wood sprouts. Damage done is mainly along paths travelled by cattle and is relatively small. Horses more destructive than cattle. Benefits of grazing outweigh injuries. Detailed tables given showing number and extent of injuries over various plots.—*G. R Taylor.*

Erosion and Floods in the Yellow River Watershed. W. C. Lowdermilk. Journal of Forestry, 22: 6, 11–18, October 1, 1924. Discusses precipitation and erosion of Yellow River, China. Flood region has lowest rainfall of all China. Silt is main factor in flood problem, the river water averaging 5 per cent by weight of silt. Reforestation of talus slopes recommended for solution of problem.—*G. R. Taylor.*

The Role of Fire in the California Pine Forests. E. B. Show and E. I. Kotok. U. S. Dept. Agriculture Bulletin 1294, 80 p., December, 1924. Detailed account of fire damages to California pine forests. Pp. 44–45; discusses damage to Watersheds, with especial reference to erosion and irrigation — *G. R. Taylor.*

New York State Park Bond Issue Wins. Am. Forests, 30: 372, p. 758. December, 1924. Fifteen million dollar bond issue voted for state parks: five million to be used to acquire forest lands in Catskills and Adirondacks to protect watershed and stream flows in those areas.—*G. R. Taylor.*

Watershed Cover Values Recognized in California. A power Company assessed damage for a forest fire. Among damages which court enumerated was one of 35 cents per acre for brush as watershed cover.—*G. R. Taylor.*

Acreage Added to National Forests in East and South. American Forests, 30: 369, 570–72, September, 1924. 102,000 acres purchased in East and South in July for National Forests under Weeks Act for protection of watersheds of navigable rivers. Average price $4.16 per acre.—*G. R. Taylor.*

Vermont Knows Value of Municipal Forests. Am. Forests, 30: 371, 697, November, 1924. 15 Municipalities in Vermont own forest land, in part for watershed protection, part for city forests. Rutland owns 1500 acres and has planted 400,000 trees.—*G. R. Taylor.*

NEW BOOK

General Systematic Bacteriology. R. E. Buchanan, Ph.D. The Williams & Wilkins Company, Baltimore, 1925. This volume is the first of a series of monographs upon the subject of systematic bacteriology. It is the latest authoritative work in this field. The purposes of this series are to further clarify our understanding of the phylogeny and relationships of bacteria, to correct error in the present system of nomenclature by establishing true priority, etc., and to prevent unnecessary confusion in nomenclature.

The present volume is not a manual of determinative bacteriology. It is a collection and compilation of very valuable material, which may form the basis for a true systematization of bacteriology.

The book is divided into three main portions, exclusive of author's preface and bibliography. The first chapter, some ninety pages in length, presents in interesting form and considerable detail a history of the long attempt of bacteriologists to systematize their subject. The history starts with an account of the simple system of Mueller (1773) and ends with a brief presentation of the elaborate manual arranged by a committee of the Society of American Bacteriologists, and published in 1923. The various changes, additions to and omissions in the successive systems are commented upon or illustrated by specimen keys and systems. One is impressed with the fact that order may yet come out of chaos.

The second chapter, comparatively short, is a review of various codes of

nomenclature. The code of Lehmann and Neumann, the rules of the International Botanical Congress (1910), the international rules of zoological nomenclature, the type-basis code of the Botanical Society of America, and the suggestions made by the committee of the Society of American Bacteriologists, are given in detail with paragraph commentaries by the author throughout. The type basis code of the Botanical Society of America is adopted by the author as best serving the needs of bacteriologists. He does not, however, abandon the international code and even refers to the zoological code where the others are inapplicable.

The third chapter, over three hundred pages in length is a sort of gazeteer of names of bacterial groups ranging in importance from sub-genera up to classes. It lists alphabetically all names which have been applied to various groups either as truly proposed names or as casual references. Each term is followed by a discussion of its orign, meaning, history, validity, etc. For example, the discussion of the term "bacillus" covers about seven pages.

The volume includes a bibliography containing about five hundred references.

The work as a whole throws new light in the dark places of systematization. The enormous amount of research done and the difficulties overcome in obtaining the correct origins, priorities, etc., become evident to one reading the volume. The information contained should be welcomed by all who are interested in placing bacterial nomenclature and systematization in their rightful places.—*Martin Frobisher, Jr.*